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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXV.—No. 2984.] *LONDON: FRIDAY, MARCH 9, 1923.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

Aveling & Porter, Ltd., ROCHESTER. 1108

Steam Road Rollers & Tractors.

A. G. Mumford, Ltd., CULVER STREET WORKS, COLCHESTER. ON ADMIRALTY AND WAR OFFICE LISTS. ENGINES for Torpedo Boats, Yachts, Launches. BOILER FEED PUMPS. See advertisement pages 26 and 37. PATENT WATER-TUBE BOILERS. AUTOMATIC FEED REGULATORS. And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant OF ALL DESCRIPTIONS. FLOATING CRANES. COAL BUNKERING VESSELS. Werf Conrad, HAARLEM, HOLLAND. Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C. 2. See half-page Advert. last week and next week. 675

Cranes.—Electric, Steam, HYDRAULIC and HAND, of all types and sizes. GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 1137

STEEL TANKS, PIPES, GASHOLDERS, &c.

Thos. Piggott & Co., Limited, BIRMINGHAM. 1241 See Advertisement last week, page 9.

Spencer-Hopwood & Kirke PATENT BOILERS See Page 82. 1293 Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives. Specification and Workmanship equal to Main Line Locomotives. R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1133

Cochran MULTITUBULAR AND CROSS-TUBE TYPES. Boilers. See page 17. 1134

E. J. Davis, M.I.Mech.E., Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London." Great Eastern Road, Stratford, E. 15. 1794

Brett's Patent Lifter Co. LIMITED. Hammers, Presses, Furnaces, COVENTRY. 610

Invincible Gauge Glasses. BUTTERWORTH BROS., Ltd., Newton Heath Glass Works, Manchester. Od 9753

Electric Cranes. 1074 S. H. HEYWOOD & CO., LTD., REDDISH.

Fuller, Horsey, Sons & Cassell. SPECIALISTS in the SALE AND VALUATION of PLANT AND MACHINERY and ENGINEERING WORKS. 11, BILLITER SQUARE, E.C.3. 1834

Iron and Steel Tubes and Fittings. Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817 The Scottish Tube Co., Ltd., HEAD OFFICE: 34, Robertson Street, Glasgow. See Advertisement, page 67, March 2.

YARROW & CO. (1922), LTD., GLASGOW. PASSENGER AND CARGO STEAMERS, SHALLOW DRAFT VESSELS. 818

Campbells & Hunter, Ltd. Gear Cutting. Worm Wheels cut up to 12 ft. diam. Bevel and Mitre Wheels planed up to 3 ft. diam. Spur Wheels cut up to 9 ft. diam. DOLPHIN FOUNDRY, LEEDS. 4547

Vosper & Co., LTD., PORTSMOUTH. SHIP & LAUNCH BUILDERS, Od 3551 ENGINEERS & BOILER MAKERS.

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Locomotives Tank Engines designed and constructed by MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od. 2487 See their Illus. Advertisement, page 85, last week. RAILWAY AND TRAMWAY ROLLING STOCK.

Hurst, Nelson & Co., Ltd. THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

R. Y. Pickering & Co., Ltd., (ESTABLISHED 1864.) BUILDERS of RAILWAY CARRIAGES & WAGONS MAKERS of WHEELS and AXLES of all kinds. RAILWAY WAGONS FOR HIRE. Chief Works and Offices: WISHAW, near GLASGOW. London Office: 3, VICTORIA STREET, WESTMINSTER, S.W. Od 8353

Henry Butcher & Co., AUCTIONEERS, VALUERS AND SURVEYORS for ENGINEERING AND ALLIED TRADES and INDUSTRIAL PROPERTIES. 9866 63 and 64, CHANCERY LANE, LONDON, W.C.2.

Electric Transporters. S. H. HEYWOOD & CO., LTD., REDDISH. 1074

Rosser and Russell, Ltd., MECHANICAL ENGINEERS. QUEEN'S WHARF, HAMMERSMITH, W. Undertake SPECIAL MACHINE WORK of any description. WELL EQUIPPED SHOP. LATHE WORK up to 10 ft. diameter. *Phone:* Hammersmith 31, 967. 9211

For Your Repairs or any SPECIAL MACHINERY, try— THOMAS HUNT & SONS, Albion Ironworks, Bridge Road West, Battersea, S.W. 11. Est. 1854. 1313

Powering of Vessels.—A Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1049, Offices of ENGINEERING.

John Bellamy, Limited, MILLWALL, LONDON, E. 1216 GENERAL CONSTRUCTIONAL ENGINEERS, Boilers, Tanks, & Mooring Buoys STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL Tubes AND Fittings AND Steel Plates. STEWARTS AND LLOYDS, Ltd. GLASGOW - BIRMINGHAM - LONDON. See Advertisement Page 93. 1111

Suitable for Light Railway, Tramway and General Power Transmission. A complete GENERATING PLANT of 1000 Kw. capacity is available for immediate delivery, comprising two 500 Kw. high-speed, enclosed, Compound Engines and Dick-Kerr Dynamos, 500/550 Volts D.C., Allen's Surface Condensing Plant, Edwards' and other Pumps, Baker Separator, piping, valves, &c., complete. Very low price—excellent condition. Also DIESEL ENGINES, 850/1200 HP. JENNINGS, West Walls, Newcastle-on-Tyne. 978

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The Glasgow Railway Engineering Company, GOVAN, GLASGOW. LTD., London Office—12, Victoria Street, S.W. MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES. CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1234

SPECIFY WELDLESS STEEL CHAIN. The Strongest Chain IN THE WORLD. 898 Sole Manufacturers: WELDLESS CHAINS, LTD., 50, WELLINGTON STREET, GLASGOW.

ON ADMIRALTY LIST.

John Kirkaldy, Ltd., London Office: 101, LEADENHALL ST., E.C 3. Works: BURNT MILL, near HARLOW, ESSEX. Makers of Evaporating and Distilling Plants. Refrigerating and Ice-making Machinery. Feed Water Heaters. Evaporators. Fresh Water Distillers. Main Feed Pumps. Combined Circulating and Air Pumps. Auxiliary Surface Condensers, &c., &c. 846

Electric Lifts (UP TO 35 TONS.) S. H. HEYWOOD & CO., LTD., REDDISH. 1074

THE GLASGOW ROLLING STOCK AND PLANT WORKS. Hurst, Nelson & Co., Ltd., Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK. Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS. PRESSED STEEL WORK OF ALL KINDS. Registered Office and Chief Works: Motherwell. London Office: 14, Leadenhall Street, E.C. Od3382

Carels Diesel & Steam Engines. 1120 CARELS DIESEL & STEAM ENGINES (LONDON), LTD. Carlton House, Regent Street, London, S.W. 1. Telephone: Regent 3484.

Royles Limited, ENGINEERS, IRLAM, MANCHESTER. FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } ROW'S PATENTS. Merrill's Patent TWIN STRAINERS for Pump Suctions. SYPHONIA STEAM TRAPS, REDUCING VALVES High-class GUNMETAL STEAM FITTINGS. WATER SOFTENING and FILTERING. 5723

YARROW & CO. (1922), LTD., GLASGOW. LAND AND MARINE YARROW BOILERS. 819

Matthew Paul & Co., Ltd., LEVENFORD WORKS, Dumbarton. 763 See Full Page Advt., page 56, March 2.

Forgings. Walter Somers, Limited, HALESOWEN. 7116

Taylor & Challen Presses For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER. Foundry, Works, and Showrooms: BIRMINGHAM. See half page advert., page 59, March 2. 8195

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS. Forgings, Castings, Bars, Sheets, Wire, Tubes. THE DELTA METAL CO., LTD., 1334 E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

For all Classes of Drawing, TRACING AND PHOTO PRINTING, send your orders and enquiries to the North West Drawing Office, 2, High St., Harlesden, London, N.W. 10. 1080

Railway Switches and Crossings. T. SUMMERSON & SONS, LIMITED, DARLINGTON. 1319

'Phone—Holb. 541. Tele.—Andrubo, Holb., London. Andrews & Beaumont, CHARTERED PATENT AGENTS, 1292 29, Southampton Buildings, London, W.C. 2.

Patents and Trademarks:— Inventors Advise, Handbook and Consultations free.—KINGS PATENT AGENCY, LTD. (B. T. King, Director), 146a, Queen Victoria Street, London. 36 years refs. 1209

Locomotive Traversers (ELECTRIC). S. H. HEYWOOD & CO., LTD., REDDISH. 1074

P. & W. MacLellan, Ltd., CLUTHA WORKS, GLASGOW. MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION. RAILWAY IRONWORK, BRIDGES, ROOFING, &c. Chief Offices: 129, Trongate, Glasgow. Od 8547 Registered Offices: Clutha House, 10, Princes St., Westminster, S.W. 1.

Centrifugals. Pott, Cassels & Williamson, MOTHERWELL, SCOTLAND. 909 See half-page Advertisement, page 66, Feb. 16.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by Mr TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1295

A Brochure describing our

Special Course of training in the lucrative field of "ENGINEERING SALESMANSHIP and SALES MANAGEMENT" will be sent on application to DIRECTOR, THE INSTITUTE OF ENGINEERING SALESMANSHIP, 333, Oxford Rd., Manchester. 1119

TENDERS.

EAST INDIAN RAILWAY.

The Directors are prepared to receive up to Eleven o'clock a.m. on Wednesday, the 28th March,

Tenders for the Supply of:—

(1) ELECTRIC OVERHEAD TRAVELLING CRANES, &c.
(2) WHEEL LATHES.

Copies of the Specifications can be obtained at the Company's offices on payment of £1 1s. each. This fee will not be returned.

G. H. LILLIE,
Secretary.

73-76, King William Street,
London, E.C.4.
7th March, 1923. X 848

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form, Specification, Contract Conditions and Drawings may be obtained or inspected at the office of

THE AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.

SPECIFICATION No. 23/28.
WATER SCREENING PLANT.

Prospective tenderers without Australian Representation should note that time does not permit of their detailed Tender being received at this Office by date of closing of Tenders, and should therefore cable direct, the following particulars:—

1. Price.
2. Delivery.
3. Particulars marked with an asterisk in the Schedule of Plant details.
4. Whether or not one set may be delivered before the complete plant, and if so at what date.

Detailed Tender on prescribed form should be posted by earliest possible mail.

The Commission does not bind itself to accept the lowest or any Tender.

R. LIDDELOW,
Secretary.

State Electricity Commission of Victoria,
Melbourne, Australia. X 726

URBAN DISTRICT COUNCIL OF WINDLESHAM (SURREY).

NEW SEWERAGE AND SEWAGE DISPOSAL SCHEME FOR BAGSHOT, LIGHTWATER AND WINDLESHAM.

UNEMPLOYMENT RELIEF WORKS.
GENERAL CONTRACT.

The Urban District Council of Windlesham invite

Tenders from Responsible and

Experienced Contractors for the CONSTRUCTION of these WORKS, which comprise about 10 miles of Stoneware and Cast-Iron Sewers, Brick, Concrete and Cast-Iron Manholes, Flushing Tanks, Ventilating Shafts and Columns, Cast-Iron Rising Mains, Air Mains, Engines, Compressors, Ejectors, Ejector Stations, Engine Houses, Balancing, Detritus, Sedimentation, Upward Flow, Storm, Humus and other Tanks, Percolating Filters, Laying Out Storm Water Area, Roads, Paths, and other incidental works.

A copy of the Specification and Form of Tender may be obtained on application, in writing, to MAJOR T. J. MOSS-FLOWER, Civil Engineer, 28, Victoria Street, Westminster, S.W., and Carlton Chambers, Bristol, at his Bristol Office, on and after 5th March, 1923, on deposit of a £10 Bank of England Note, which will be refunded provided a *bona fide* Tender be received, and is not withdrawn before the sealing by the Council of one of the Tenders, and provided also that all documents supplied be returned to the Engineer. On production of a receipt for the deposit, persons tendering may inspect the plans at Bagshot on a day and at a time and place which will be communicated to them.

The Contractor carrying out the work will be required to comply with the regulations of the Unemployment Grants Committee with regard to the employment of labour during the performance of the Contract.

Sealed Tenders, endorsed "Tender for Bagshot, Lightwater and Windlesham Sewerage and Sewage Disposal Works, General Contract," are to be delivered at the Council Offices not later than Noon on 27th March, 1923.

The lowest or any Tender will not necessarily be accepted.

Dated this 24th day of February, 1923.

(By Order),
EDWYN T. CLOSH,
Solicitor and Clerk to the Council.

Council Offices,
Bagshot (Surrey). X 731

SALE BY TENDER.

Tenders are Invited for

the PURCHASE, DISMANTLING and REMOVAL of PLANT (four steam-driven generating sets with fittings, &c., &c.), lying at the Post Office Savings Bank, Blythe Road, Kensington, London, W.14.

Also for the PURCHASE, DISMANTLING and REMOVAL of PLANT (Boilers, Electric Motors, &c.), lying at the Head Post Office, Liverpool.

TENDERS FOR EITHER OR BOTH WILL BE RECEIVED UNTIL TEN A.M. on THURSDAY, the 22nd MARCH, 1923.

Forms of Tender containing all particulars can be obtained on application to the CONTROLLER, POST OFFICE STORES DEPARTMENT, STUDD STREET DEPOT, ISLINGTON, LONDON, N. 1.

The Postmaster-General does not bind himself to accept the highest or any Tender.

By Order of the
POSTMASTER-GENERAL.

GENERAL POST OFFICE,
March, 1923. X 836

COUNTY OF LONDON.

The London County Council invites

Tenders for the Manufacture,

SUPPLY and ERECTION at Greenwich Power Station of (1) PIPEWORK (Steam and Feed), (2) MOTOR DRIVEN FEED PUMP.

The Specification, Form of Tender, and General Conditions may be obtained from the Clerk of the Council, The County Hall, Westminster Bridge, S.E. 1 (Room No. 215), upon payment to the Cashier of the Council of a deposit of £3. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Particulars of the work may be obtained on application at the County Hall before the payment of the fee.

Tenders must be addressed to the Clerk of the Council and delivered at the County Hall, Westminster Bridge, S.E. 1, not later than Four p.m. on Monday, 26th March, 1923. No Tender received after that time will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council.
X 842

METROPOLITAN ASYLUMS BOARD.

Tenders are Invited for the

PURCHASE of TWO SECOND-HAND GARRETT TRACTORS as under:—

(A) ONE No. 4 Compound Motor Tractor, No. 33,078, manufactured in 1917, insured with the Manchester Steam Users Association for a working pressure of 180 lbs. per square inch. This Tractor can be viewed at Darenth Training Colony, near Dartford.
(B) ONE No 4 Compound Tractor, No. 32,985, manufactured in 1917, insured with the National Boiler and General Insurance Co. for a working pressure of 200 lbs. per square inch. This Tractor can be viewed at Leavesden Mental Hospital, King's Langley, Herts.

The following details apply in each case:—

Axle weight, front 2 tons, hind 2 tons 2 cwts. Diameter of wheels, 3 ft. 7 in. front wheels, 5 ft. hind wheels. Width and material of tyres, front 6 in. steel, hind 12 in. steel. Speed, 5 miles per hour. Unladen weight, 4 tons 19½ cwts.

Also FOUR TRAILERS, built by Messrs. Garrett and Son, suitable for use with either of the above-mentioned Tractors.

These Trailers are on view at Darenth Training Colony, near Dartford, Kent.

The Tractors or Trailers may be purchased separately, or in one lot as a whole, and may be inspected between the hours of Ten a.m. and Four p.m. on ordinary week days, or between Ten and Twelve on Saturdays, on production of the Tender Form.

Form of Tender, upon which alone offers will be considered, may be obtained from the undersigned.

Tenders, addressed as printed on the form, may be obtained from the Offices of the Board, Embankment (Corner of Carmelite Street), E.C. 4., and must be returned duly filled in not later than Ten a.m. on Monday, 26th March, 1923.

By Order,
G. A. POWELL,
Clerk to the Board.
March, 1923. X 807

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

ELECTRIFICATION OF SUBURBAN LINES.

The Directors are prepared to receive

Tenders for the Supply of

certain PLANT in connection with the first instalment of the electrification of the above lines, namely:—

	Fee for Specification.
No. 1.—Transformers...	£3.
No. 2.—Cables	£2.
No. 3.—Switchgear and Accessories	£2.
No. 4.—Converter Sets	£2.

Specifications and Forms of Tender may be obtained at this office on and after the 12th March, 1923, on payment of the fee for the Specification, which payment will not be returned.

Contractors may Tender for all or any of the above Sections.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Transformers" or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 24th April, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

The Consulting Engineers to whom applications for any further technical information may be made are Messrs. MERZ & MCLELLAN, 32, Victoria St., Westminster, S.W. 1.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London. X 835

TO BAKERY ENGINEERS AND OTHERS.

The Metropolitan Asylums Board invite

Tenders for the Installation

of a NEW STEAM-PIPE PEEL OVEN at the North-Eastern Fever Hospital, St. Anne's Road, Tottenham, N. 15, in accordance with drawing and specification prepared by Mr. T. COOPER, M.Inst. C.E., M.I.Mech.E., Engineer-in-Chief.

The Drawing, Specification, and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C. 4, on and after Ten a.m., on Wednesday, 14th March, 1923, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender, and after the specification and the drawing have been returned.

Tenders addressed as noted on the Form must be delivered at the Office of the Board not later than half-past Two p.m. on Wednesday, 28th March, 1923.

(By Order) G. A. POWELL,
Clerk to the Board.
X 849

MANCHESTER CORPORATION WATERWORKS.

The Waterworks Committee invite

Tenders for the Supply and

ERECTION at their Lostock Booster House, near Bolton, of the following PLANT, viz.:

CONTRACT No. 2.—TWO 300 Kw. ROTARY CONVERTERS with Static Transformers, H.T. and L.T. Switchgear, &c.

CONTRACT No. 3.—FOUR ELECTRICALLY-DRIVEN CENTRIFUGAL PUMPS to deliver 3000/4000 gallons per minute against a head of from 40/60 feet, together with Switchgear, pipes, valves, &c.

Specifications and Forms of Tender may be obtained on application to the Secretary Waterworks Offices, Town Hall, Manchester, on payment of Two Guineas for each Contract, which sums will only be returned on receipt of *bona fide* Tenders.

Any other information required respecting the work may be obtained from the Waterworks Engineer.

Sealed tenders, endorsed as directed, must be delivered at the Waterworks Offices, Town Hall, Manchester, not later than the 7th April, 1923.

By Order,
P. M. HEATH,
Town Clerk.

Town Hall, Manchester,
5th March, 1923. X 816

TENDERS INVITED.

COUNTY OF LONDON ELECTRIC SUPPLY CO., LTD.

BARKING POWER STATION.

The County of London Electric Supply Company, Limited, are open to receive

Tenders for the Supply and

ERECTION of the COMPLETE PIPING EQUIPMENT for their Barking Power Station, including Steam, Water and Compressed Air Piping, Water Storage Tanks, and Auxiliary Pumps.

Specifications may be obtained by manufacturers from the Offices of the Company on application to the undersigned, on or after March 9th, 1923, and on payment of a fee of Five Guineas for the first copy and Two Guineas for each subsequent copy.

Sealed Tenders, marked "Tender for Piping Equipment for Barking Power Station," are to be addressed to the Chairman and Managing Director, and lodged at the Registered Office of the Company by Noon on April 10th, 1923.

Sums paid for any number of Copies up to three will be refunded on receipt of a *bona fide* Tender.

The Company do not bind themselves to accept the lowest or any Tender.

F. G. MCQUOWN,
Manager and Secretary.
County of London Electric Supply Co., Ltd.,
Moorgate Court, Moorgate Place, E.C.
X 827

METROPOLITAN WATER BOARD.

TENDERS for the MANUFACTURE, DELIVERY and FIXING of FOUR LANCASHIRE BOILERS, PIPING, etc., at the Lee Bridge Pumping Station, Essex.

The Metropolitan Water Board invite

Tenders for the Manufacture,

DELIVERY and FIXING of FOUR LANCASHIRE BOILERS, Superheaters, Economiser, Piping, Feed Pumps, etc., at their Lee Bridge Pumping Station, Essex.

Forms of Tender, Conditions of Contract, Specification and Drawings may be inspected without payment of fee at the Offices of the Board, Chief Engineer's Department, Room 173, 173, Rosebery Avenue, Clerkenwell, E.C. 1, on and after Saturday, 10th March, 1923.

Contractors desirous of tendering may obtain the necessary documents from Mr. HENRY B. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of Three Guineas, which sum must be deposited with the Board's Accountant, and will be returned on receipt of a *bona fide* Tender, together with all incidental papers. Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and Twelve Noon). Cheques must be made payable to the "Metropolitan Water Board" and not to individuals.

Tenders enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1," and endorsed "Tender for Boilers, Lee Bridge," must be delivered at the Offices of the Board not later than Ten a.m. on Wednesday, 4th April, 1923.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery Avenue, E.C. 1.
1st March, 1923. X 813

BRAINTREE UNION.

TENDERS FOR BOILER.

The Guardians of the above Union invite

Tenders for the Supply and

FIXING COMPLETE of a NEW CORNISH BOILER, size 12 feet by 4 feet 6 inches, with necessary fittings complete. A specification containing necessary details and other information can be obtained on application to the Assistant Clerk, 71, Rayne Road, Braintree, to whom Tenders should be addressed in Sealed Envelopes marked "Boiler Tender." Tenders to be sent in not later than Wednesday, the 14th March, 1923.

The Guardians do not bind themselves to accept the lowest or any Tender. X 778

ALFRED HILLS,
Clerk to the Guardians.

APPOINTMENTS OPEN.

UNIVERSITY OF LONDON.

The Senate invite

Applications for the Ramsay

Memorial CHAIR of CHEMICAL ENGINEERING tenable at University College.—Full particulars may be obtained from the ACADEMIC REGISTRAR, University of London, South Kensington, London, S.W.7. X 779

THE ROYAL TECHNICAL COLLEGE, GLASGOW.

The Governors invite

Applications for the Chair of

ELECTRICAL ENGINEERING, from which Professor Magnus Maclean, M.A., D.Sc., LL.D., is about to retire. Salary £1000.

Applications and testimonials should be sent, not later than 22nd March, to the DIRECTOR of the COLLEGE, from whom further particulars may be obtained. X 807

CITY AND GUILDS (ENGINEERING) COLLEGE.

There is a Vacancy for a

LECTURER in the Department of Mechanical Engineering and Motive Power. Practical experience and an Honours Degree of a British University or an equivalent academic qualification are essential. Salary £400 per annum, of which 5% must be contributed to the Universities Federated Superannuation Scheme.

Apply in the first instance to Professor W. E. DALBY, F.R.S., City and Guilds (Engineering) College, Exhibition Road, London, S.W. 7, on or before March 19th. X 817

Wanted, Metallurgist for

large Manufacturing Plant in Scotland; must have had experience in research work and acquainted with modern methods of heat treatment of steel. State qualifications and last employer. Replies will be treated confidentially.—Address, METAL, WM. PORTEOUS & Co., Advertising Agents, Glasgow. X 675

Heating.—Wanted, Man

experienced in the operation of large heating installations on the exhaust steam vacuum return system, who is accustomed to preparing preliminary layout drawings of piping. State in what capacity employed, giving location and size of recent installations. State age, wage expected, and give references.—Address, VACUUM, WM. PORTEOUS & Co., Advertising Agents, Glasgow. X 788

Wanted, Town Superintendent

for Water Works on East Coast. Population about 60,000. Experience in distribution, main-laying, waste detection, keeping of pipe plans and records, plumbing, fittings, meters, stores and Office routine. Good management of all classes of workmen. Salary £300 per annum with house. Age 30 to 45. Application in own handwriting with three recent testimonials.—Address, X 801, Offices of ENGINEERING.

MERSEY DOCKS AND HARBOUR BOARD.

Principal Timekeeper Re-

QUIRED for Engineer's Department. Candidates, not in the Board's employ, to be under 40 years of age, and must have had experience in large Works employing all classes of Tradesmen and Labour, and also have been a senior on or in charge of a Timekeeping Staff.

Applications, forwarding copy testimonials, and stating age, experience, etc., and salary required, to be marked on the envelope "Application, Principal Timekeeper," addressed to the Undersigned, and delivered before March 15.

L. A. P. WARNER,
General Manager and Secretary.

Dock Office, Liverpool.
March 1, 1923. X 790

BOARD OF TRADE, STANDARDS DEPARTMENT.

A Vacancy Exists for an

ASSISTANT EXAMINER in the Standards Department of the Board of Trade with establishment in H.M. Civil Service after two years' approved service. The duties are mainly in connection with the examination of weighing and measuring apparatus of novel types with a view to their approval for use in trade.

Candidates, who must be British subjects by birth, and the sons of fathers also British subjects by birth, should possess a University Degree (or its equivalent) in Science or Engineering and should have had practical workshop experience. Preference will be given to ex-Service men.

The salary is £150, rising by £15 to £300 per annum, with bonus which is re-assessed half-yearly on the basis of the average cost-of-living figure for the previous six months. The present bonus on £150 is £94 14s. 0d., making the total remuneration £244 14s 0d.

Applications, with copies of Testimonials, should be made in writing to the PRINCIPAL ESTABLISHMENT OFFICER, Board of Trade, Great George Street, Westminster, S.W. 1, not later than the 17th March, 1923. X 799

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LITERATURE.

American Malleable Cast-Iron. By H. A. SCHWARTZ. The Penton Publishing Company, Cleveland, Ohio, U.S.A. European Headquarters, 2–3, Caxton House, Westminster, London, S.W.1. [Price 35*s.* net.]

MALLEABLE cast-iron is probably one of the least known of the products of ferrous metallurgy, and Mr. Schwartz's book is certain to be well received by all engineers and metallurgists. The literature on the subject is limited, and we feel that the present work will supply a long-felt want.

In a brief historical survey the author gives prominence to two names, viz., Réaumur, the great pioneer, and Seth Boyden, the original producer of "black-heart" malleable cast-iron and founder of that industry in the United States of America.

The difference between so-called European "white-heart" and American "black-heart" malleable iron is explained in detail. In the former case the original casting is entirely decarburised by prolonged annealing in a surrounding packing material rich in oxygen. In the latter case decarburisation is not aimed at, the original white-iron castings are annealed in similar fashion, except that the packing used consists mainly of silicates and contains little free oxide; a certain amount of carbon is oxidised, but this is a mere incident in the process. The packing, although practically inert, serves the useful purpose of supporting the castings, while hot, and preventing excessive scaling. The process involves no change in the ultimate chemical composition, all the elements remaining unaltered in quantity. The carbon alone is converted from the combined to the free amorphous state, and is termed "temper carbon." The micro-aspect of the material shows nodules of temper-carbon in a matrix of ferrite. Temper carbon is always a decomposition product of previously-formed cementite, since the casting before annealing consists only of cementite and pearlite.

Black-heart malleable iron, so called on account of the greyish appearance of the fracture, is the subject of the present work. It is undoubtedly in many respects an exclusively American product (hence the book-title) and the great development of the industry, as shown by the author, is indicative of its importance in that part of the world.

Having fully gone into such subjects as melting stocks, air and electric furnace melting, cupola and open hearth melting, and the production of sound white-iron castings generally, the author devotes two chapters to the all-important subject of annealing. The higher the annealing temperature, the more rapidly will the graphitisation of cementite take place, this being especially the case if the percentage of silicon is within the recognised limits. The above facts are well known and it would seem advantageous, therefore, to conduct the process at the highest possible temperature. There are many objections, however. A high temperature softens and distorts the castings, fuses the packing, greatly increases wear and tear, and consumes much additional fuel. The structure of the resulting material is very bad and consists of coarse ferrite grains and large flakes of carbon. The author considers that the range 1,500 deg. to 1,700 deg. F. gives the best results, and recommends the following 115-hour or six-day cycle as an absolute minimum:—(1) Heating to 1,600 deg. F., 30 hours; (2) holding at 1,600 deg. F., 45 hours; (3) cooling to Ar_1 and holding there, 35 hours; and (4) cooling to handle, 5 hours. Seven-day cycles are usual in commerce, while periods of nine days or more are not uncommon in the case of large furnaces.

The applications of "malleable" are many and various; at first used in the manufacture of such relatively unimportant articles as buckles and harness parts, it was largely responsible for the production of agricultural implements at moderate prices. Railway rolling-stock and motor-car builders absorb large quantities of the material, which, in the author's opinion, is steadily increasing in importance, new applications being continually found for it in many industries. During the war it was used for making such articles as hand and rifle grenades and trench-mortar shells.

The sections dealing with fuel and refractories, pattern-making and moulding, cleaning and finishing inspecting and testing, and the mechanical, thermal and electric properties of the material under consideration are thorough and well set out. The illustrations, maps and diagrams are numerous and excellent, and the various series of photo-micrographs, capital.

There are one or two minor blemishes which will no doubt be corrected in a later edition; we refer to the incorrect spelling of the names of Sir W. C. Roberts-Austen and Dr. Carl Benedicks, and the title of the periodical "*Annales de Chimie et de Physique*" (page 33). The term "mix-crystals" (or "mixed-crystals") used in some places as a synonym of "solid solution" is obsolete. The word comes from the German "misch-kristalle" and has also crept into the French language as "cristaux-mêlés" or "cristaux mixtes." A solid-solution may indeed be described as being an intimate, homogeneous mixture of "*molecules*" following certain fixed and well-defined laws, but the term "mixed-crystals" is unfortunate and misleading, and should be abandoned by all modern technologists.

Throughout the book, the author speaks with the enthusiasm of conviction, and a high standard is maintained from beginning to end. His great aim seems to be to dispel any misconception which may exist as to the manufacture, properties and usefulness of American "black-heart" malleable cast-iron. He quotes what has been done and what can be accomplished, and in all cases his statements are backed by sound theory.

The Flow of Gases in Furnaces. By W. E. GROUME-GRJIMAILO. Translated from Russian into French by LEON DLAUGATCH and A. ROTHSTEIN. With a preface by HENRY LE CHATELIER. Translated from the French by A. D. WILLIAMS. With an appendix upon the Design of Open-hearth Furnaces. New York: Wiley and Sons, Inc.; London: Chapman and Hall. [Price 27*s.* 6*d.*]

ANY treatise having reference to the application of heat to industrial purposes and recommended by M. Le Chatelier would meet with respectful attention, but the hope of improving the design and construction of furnaces and of substituting scientific principles for empirical rules, gives a keener interest to this volume, in the preparation of which in its present form several authorities have co-operated. The author of the portion more particularly connected with the description of the circulation of heated gases, M. G. Grjimailo, after many years' practical experience in the engineering works of the Oural region, acquired a wide reputation as Professor of iron manufacturing in the Polytechnic Institute of Petrograd, and rightly commands our confidence. MM. L. Dlaugatch and the late A. Rothstein were very competent critics, and their translation affords abundant testimony that they approved the methods and conclusions of the Russian professor; while Mr. Williams, to whom we are indebted for an English translation, is a recognised authority in both England and America. Yet we cannot altogether put aside the impression that good fortune rather than well-grounded analyses has fought on the side of M. Grjimailo. His conclusions may be, and we believe are, warranted, they embrace much practical experience, but his methods of deduction are open to question. The principle of analogy, on which he relies to carry convictions to pupils and opponents alike, has always some point of weakness, which should prevent the obvious conclusions being accepted as legitimate demonstration. In this case the author claims that the circulation of a coloured, light kerosene oil, in contact with a denser liquid as water, which may be observed in a model built with glass sides, imitates the behaviour of currents of gas having different densities, and that "the movement of the lighter liquid will reproduce exactly the movement of flames within a furnace." Such models are admirably adapted for class instruction, and may be used to stimulate the imagination of those who may not be well informed regarding the laws of elementary physics, but there are essential differences between oil and water on the one hand, and gases at different temperatures on the other, which may lead the judgment astray. The phenomena of diffusion of gas elude observation, the transformation of light and hot gas into heavier and cooler gases introduces a fresh fact which certainly cannot be ignored.

The model is not used simply for illustration, its proper function, but definite conclusions are drawn from the relative motions of kerosene and water. For instance, it is used to show that the effect of a furnace roof sloping upwards is to increase the velocity of hot gases and to decrease the thickness of the stream. The conclusion is probably correct, but the method adopted for proving it is not convincing. In the model furnace made to represent the conditions, the kerosene failed to drive out the water, and it is therefore concluded that the rise of the hearth constituted a "pocket" from which the cooler and heavier gases cannot flow. On increasing the current of kerosene, some of the oil escaped through the small space between the sheets of glass forming the sides of the model. "It is evident that this is not a desirable method of working," says the author, "as the outflow of the chilled gases from the hearth will take place through the working doors instead of through the waste gas opening to the chimney. However correct this inference may be it is not deducible from the evidence submitted.

The author is aware, however, of the limitations of his model, and that though he might demonstrate the mechanism of the circulation of the hot gases he could not deduce quantitatively the dimensions of a furnace, determine the proper aperture of the ports, or the form and character of the roof, the correct height above the hearth, and other features. But he succeeded in interesting M. Yesmann, professor of hydraulics at the Polytechnic Institute, and their co-operation has proved most happy. The theory of the inverted weir may seem a little fanciful, but it illustrates the principle on which the hot gases in a furnace tend to circulate, and suggests formulæ which can be submitted to arithmetic calculation and the results compared with actual observation, leading to continual improvement in design, when the purpose of the furnace is known.

The great value of the inquiry on which M. Grjimailo has worked so long and so perseveringly is that he has convinced the engineering world that gases, notwithstanding their elasticity, do not fill completely the chamber in which they are enclosed, and that these gases as they pass through a series of successive chambers fail to fill the entire cross-section of the chambers or flues through which they pass. A practical consequence of this unequal circulation is that the hot gases may circulate only in the upper portion of the heating chamber, without coming into direct contact with the material on the hearth, and a necessary corollary is that the down-draught principle of heating, which has long been employed in the manufacture of porcelain is deserving of a wider recognition than it has obtained.

In the second part of the paper, the author endeavours to answer the question: "In what manner may the hot gases be circulated so that they will surround the objects being heated and be carried out of the heating chamber, in order that hotter gases may take their place?" Necessarily a second question arises: "How is the heating chamber to be constructed in order to obtain the most suitable circulation of the hot gases?" The method adopted for indicating correct practice is to point out the failures in existing structures. A number of designs is examined and criticism is directed to show how far they observe, and in what particulars they infringe, the rules which give the most satisfactory practical results. About 50 per cent. are shown to possess serious defects, and are well distributed among various types of furnaces and heating apparatus. In the list figure vertical and horizontal regenerators, hot blast stoves, steam boilers, brick kilns, muffle furnaces, tempering furnaces, coal-fired reverberating and Siemens regenerating heating furnaces, and many others. This list will show, however, that the offenders are by no means confined to any one type, but that the "collection of monstrosities" pervades every department of industrial heating. In some cases the designers appear to have had very primitive ideas concerning the application and utilisation of heat. We may hope that the trenchant criticism to which they have been subjected in the book under notice will go far to stabilise methods of greater economy and usefulness. The appendices to the volume are many and

valuable. Not only are many useful tables given, but Professor Yesmann gives a full explanation of the formula he recommends. M. Mojarow, by his discussion of the friction of gases in brickwork supplies data that will add to the accuracy of some previous computations. But most important of all are three papers by Mr. Williams, the English translator of this work, on the design of open-hearth furnaces: on the blast-furnace, and on steam boilers. It would be much to be regretted if these were passed over with the usual unconcern paid to the matter relegated to an appendix, for much practical information is supplied and illustrated, particularly in the matter of waste heat and faulty boiler settings. We may not always accept his conclusions, but we ought to be quite satisfied that we are justified in withholding agreement. The author gives loyal allegiance to the methods of MM. Grjimailo and Yesmann, but he is careful to say that the flow of gases must be governed by the laws of elementary physics. He uses experiment wisely for illustration, but does not make theory subservient to its indications. The paper on the design of hot-blast stoves was prompted by a desire to correct some misapprehensions concerning the laws governing the flow of heat, and the relationship between the thickness of the walls of the checker openings and the time required to saturate the heat storage capacity of the brickwork. The tables attached to this paper will repay close study.

BOOKS RECEIVED.

The Simple Lathe and Its Accessories. London: Cassell and Co., Limited. [Price 1*s.* 6*d.* net.]

Het Uitbalanceeren van Dorschtrommels en Andere Snelroteerende Machinedeelen. (Ein Nieuwe Methode). By Ir. M. W. POLAK. Wageningen: H. Veenman and Zonen.

The Swedish Year Book, 1922. Stockholm: Almqvist and Wiksells Boktryckeri-A.B.

Cements, Limes and Plasters. Their Manufacture and Properties. By EDWIN C. ECKEL, C.E. Second edition, revised. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 32*s.* 6*d.* net.]

Abstract Bulletin of Nela Research Laboratory. National Lamp Works of General Electric Company, Cleveland, Ohio. Vol. I, No. 3. *October*, 1922. EDWARD P. HYDE, Director. Cleveland, Ohio: Published by the Research Department.

Structural Design in Theory and Practice. By HENRY ADAMS, M.Inst.C.E., M.I.Mech.E. Second edition. London: Constable and Co., Limited. [Price 10*s.* 6*d.* net.]

Commonsense of the Calculus. By G. W. BREWSTER, M.A. Oxford: The Clarendon Press. [Price 2*s.* net.]

Die Baustoffkunde. Part I. *Die Hauptbaustoffe.* Part II. *Die Baustoffes des Hochbaues.* Part III. *Die Baustoffes des Tiefbaues.* By Professor H. HABERSTROH. Berlin and Leipzig: Walter de Gruyter and Co.

Textbook on Wireless Telegraphy. Vol. II. *Valves and Valve Apparatus.* By RUPERT STANLEY, B.A., LL.D, M.I.E.E. Second edition. London: Longmans, Green and Co. [Price 15*s.* net.]

The South and East African Year Book and Guide, 1923. Edited by A. SAMLER BROWN, F.R.M.S., and G. GORDON BROWN, F.R.G.S. Twenty-ninth edition London: Sampson Low, Marston and Co., Limited. [Price 5*s.* net.]

La Guerra Marittima, Studio Critico Sull' Impiego dei Mezzi Nella Guerra Mondiale. Vol. I. By ROMEO BERNOTTI. Firenze: Carpigiani and Zipoli. [Price 30 lire.]

Les Marées et Leur Utilisation Industrielle. By E. Fichot. Paris: Gauthier Villars et Cie. [Price 9 francs.]

A Dictionary of Applied Physics. Vol. III. *Meteorology, Metrology and Measuring Apparatus.* Edited by Sir RICHARD GLAZEBROOK, K.C.B., D.Sc., F.R.S. London: Macmillan and Co., Limited. [Price 63*s.* net.]

Crystallisation of Metals. Being a Course of Advanced Lectures in Metallurgy. By Colonel N. T. BELAIEW, C.B. London: University of London Press, Limited. [Price 7*s.* 6*d.* net.]

The South African Mining and Engineering Year Book, 1922–23. London: Argus South African Newspapers, Limited. [Price 10*s.* 6*d.*]

Handbook for Electrical Engineers. HAROLD PENDER, Editor-in-Chief. Second edition. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 30*s.* net.]

United States Geological Survey. Water-Supply Paper, No. 486. *Water Powers of the Cascades Range.* Part IV.: *Wenatchee and Entiat Basins.* By GLENN L. PARKER and LASLEY LEE. [Price 30 cents.] No. 490-D. *Route to Desert Watering Places in the Papago County, Arizona.* By KIRK BRYAN. Washington: Government Printing Office.

Taschenbuch der Kriegsflotten, 1923. By B. WEYER. Munchen: J. F. Lehmanns. [Price 8*s.* 6*d.*]

Railroad Construction. Theory and Practice. By W. LORING WEBB, C.E. Seventh edition, revised and enlarged. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 30*s.* net.]

United States Geological Survey. Mineral Resources of the United States in 1921. *Introduction.* By G. F. LOUGHLIN. *Summary.* By M. B. CLARK. I: 16. *Secondary Metals in* 1921. By J. P. DUNLOP. I: 17. *Gold, Silver, Copper, Lead and Zinc in California and Oregon in* 1921, *Mines Report.* By CHAS. G. YALE. I: 18. *Cobalt, Molybdenum, Nickel, Tantalum, Titanium, Tungsten, Radium, Uranium and Vanadium in* 1921. By FRANK L. HESS. I: 19. *Copper in* 1921. *General Report.* By H. A. C. JENISON. II: 34. *Coke and By-Products in* 1919–20. By R. S. MCBRIDE and F. G. TEYON. Washington: Government Printing Office.

Aeronautical Research Committee. Reports and Memoranda. No. 705. *Experiments on Complete Models of Six Aeroplanes.* By E. F. RELF, A.R.C.Sc., and E. OWER, B.Sc., A.C.G.I. [Price 1*s.* 10½*d.* post free.] No. 778. *An Electric Motor of Small Diameter for Use inside Aeroplane Models.* By E. F. RELF, A.R.C.Sc. [Price 2½*d.* post free.] London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office.

The Institute of Marine Engineers. Papers on Internal-Combustion Engines Read and Discussed at the Institute. London: Offices of the Institute. [Price 12*s.* 6*d.*]

The Young Man and Civil Engineering. By GEORGE FILLMORE SWAIN. New York: The Macmillan Company; London: Macmillan and Co. [Price 9*s.* net.]

CARBON BLACK.

CARBON BLACK is the name given to the carbon freed when burning gas with a smoky flame. It is superior in quality to the so-called lampblacks which are formed by burning solid fats, or oils, and some of the grades produced are alone suitable for the highest classes of engraving inks. It has been manufactured by burning ordinary illuminating or producer gas, but the bulk of the supplies comes from the oilfields of America where the rich gas is often burned in large works for this purpose. The quantity of gas thus consumed is said to amount to 40,000,000,000 cub. ft. per annum. The gases found to be most suitable for the production of carbon black are those containing a large percentage of ethane. For instance, in Louisiana, with a gas containing 94·12 per cent. of methane and 3·44 per cent. of ethane, only 0·8 lb. of carbon black is recovered per 1,000 cub. ft. of gas consumed, while with a Wyoming gas rich in ethane (46·45 per cent. methane and 43·10 per cent. ethane), the recovery of carbon black amounts to 1·40 lb. per 1,000 cub. ft. of gas burnt. The latter gas has a calorific value of 1,176 B.Th.U. compared with 962 B.Th.U. for the former. The previous abstraction of gasoline by the absorption process does not appear to affect the quality or quantity of carbon black which can be recovered.

The processes generally employed are mechanical. Decomposition of the gas has been attempted, but has not as yet met with general success in the commercial sense. In the mechanical systems the gas is burned with a smoky flame in contact with a smooth surface on which the carbon is deposited, to be later scraped off and collected. The mechanical devices at present employed are of four types. For three of these the output appears to be similar; for the fourth, while the output is smaller the quality is higher than with the others, and the product commands a better price as it is utilised only in special high-grade lithographic inks.

From a somewhat complicated process worked on a small scale the modern systems have been developed into greatly simplified methods operated on very extensive lines. The forerunner of the present systems used soapstone slabs as the depositing surfaces, covered with domes or roofing and kept cool by water circulation in pans. Nowadays a simple iron surface replaces the soapstone and no attempt is made to keep the surface cool. In the three processes with the largest output the surfaces used are steel channel, small iron discs and large iron plates, while in the fourth process referred to the carbon is deposited on iron rollers. The channel method has the largest total production, though as regards the size of individual plants the large channel system works only just exceed the largest plants employing the large plate method.

In the channel method the depositing is carried out in iron buildings from 80 ft. to 115 ft. long and 10 ft. to 20 ft. wide. These buildings are arranged 3 ft. apart on either side and at right angles to an alley-way 15 ft. wide. A group of such buildings is treated as a unit, the number in the group depending upon whether the depositing machines consist of one or two tables. If they are one-table buildings there will be 24 or 30 to a unit; if two-table buildings from 12 to 16 only. The output and power required per unit is thus approximately the same whether one or two tables are employed in each building. The output per unit will range from 3,000 lb. to 5,000 lb. of carbon-black per day, while the power per unit will run to from 24 h.p. to 30 h.p. Individual works run to as many as six units, totalling 180 depositing houses.

Running down the central alley-way is a gas distribution main from which two pipes are branched into each building. These pipes are laid parallel to each other down the house, and at intervals of about 8 ft. each is tapped by vertical branches. The latter at a certain height are bent over to the horizontal, and the pitch is so arranged in the two pipes that the horizontal members are spaced down the length of the house at 4-ft. intervals. Each horizontal limb carries eight tee-pieces having short vertical and longitudinal arms. The latter are set in a direction down the building, and each carries seven lava-tipped burners. Extending lengthwise down each interior there is also a light gantry supporting two rails spaced about 6 ft. apart. This gantry carries the depositing surface which is continually in motion, reciprocating through a distance of about 5 ft., each movement occupying about 15 minutes. The depositing surface consists of eight 7-in. channels arranged side by side and in 100-ft. lengths. These are bolted at intervals to pairs of cross-channels, 10-in. flanged wheels being arranged between the ends of the latter, and supporting the whole on the gantry rails. The wheels are not arranged in journals, but the stub axles roll on the underside of angle bearers. The whole "table" is oscillated by means of a rack projecting into the central alley-way down which runs, about 6 ft. above ground level, a line of shafting fitted with the necessary pinions. One shaft serves all buildings of a unit and is driven by an engine fitted with automatic belt-throwing gear for reversing.

As the eight-channel table is moved slowly over the burners, carbon black is deposited. This is removed automatically by a number of fixed scrapers as the table moves along, the scrapers operating in the best practice in one direction only. The scrapers are usually held up to the surface by a counterweight. The material removed drops into hoppers immediately below, the taper bottoms of which feed it down to a spiral conveyor running the length of the building. This runs it out to a main conveyor in the central alley-way, which thus collects the whole production of a unit. The collecting conveyor takes the material to bolting machines in another building from which it passes to hoppers feeding packing machines where it is made up in rectangular packets usually of 12½ lb. each. The separation of the carbon black from the air which it holds mechanically is the chief problem in packing. This is effected by means of a rotating rammer which is gradually pressed down inside a sheet steel tube.

In the process employing small iron discs instead of the channel tables the lay-out is somewhat different. The discs are from 36 in. to 42 in. in diameter. From 18 to 24 burners are set in a circle under each disc, and the scraper is in continuous contact with the surface. The discs revolve at the rate of once in 15 minutes and reversing is not necessary. The discs are arranged in rows of about 21, with two or four rows per building, from 16 to 20 buildings forming a unit. In an 18-building factory there would thus be about 1,532 discs. Each row of discs has a driving shaft and also its own conveyor extending down the building. The shafts are driven by gears off the main line shafting in the alley-way, as in the channel process. On the whole the material involved in the construction of this type of plant is rather less than that required for the channel process.

The large plate process employs circular plates, 24 ft. in diameter made up of inner and outer segments. In this system, either the burners are fixed and the plate revolves, or the burners revolve and the plates are fixed. The scrapers act, of course, with the burners. These large discs are mounted on central masts, the top of the latter being connected with the periphery by means of adjustable guy wires. In the case of the fixed plate machines

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

Fig. 63. SECTION A.B.

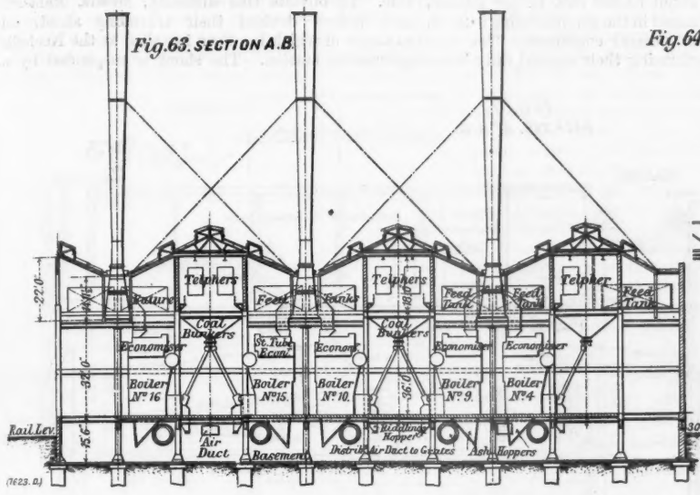


Fig. 64. SECTION C.D.

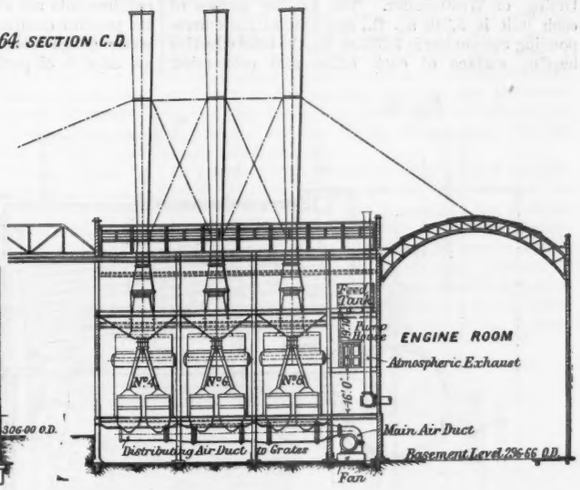
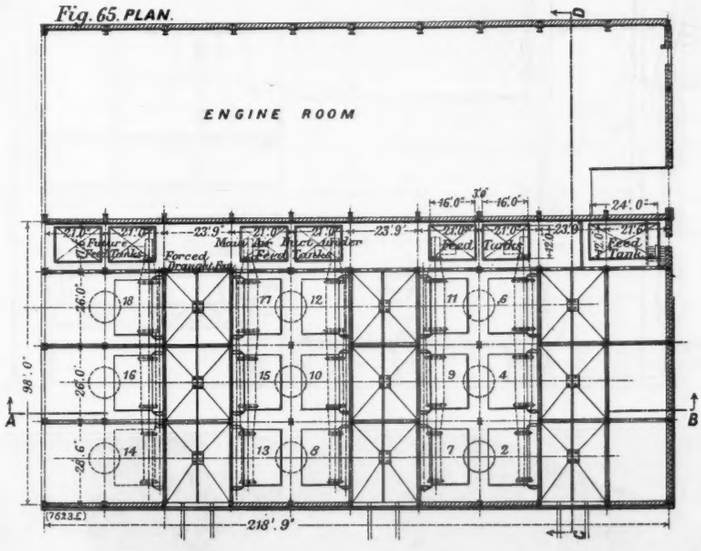


Fig. 65. PLAN.



the mast rests in a base plate and is fitted at some height above the ground with a ball bearing. Extending above this bearing is a sleeve fitted at both ends with gastight packing round the mast. Gas is admitted to the base of the mast and passing up, it is supplied through apertures to the sleeve which feeds two horizontal branch pipes set across the diameter of the plate. The burners are carried by a horizontal grid formed of parallel gas pipes, there being 1,265 tips to each plate. The burners, frame and sleeve on the mast make one revolution in 8 minutes. Radial scrapers remove the deposit which falls into radial collecting boxes below, from which it is removed by a conveyor. The conveyor works the carbon towards the centre of the rig. It falls through a vertical chute into a circular collecting box, whence it is taken by conveyor to the packing sheds. The large plates are provided with holes to allow the products of combustion to escape and the whole rig is surrounded by a circular sheet-iron wall, above which roofing extends part of the way up the mast, leaving a central opening for ventilation. A number of these machines are set in parallel lines and the masts cross-stayed to each other, the outermost being stayed to anchorages in the ground. One engine of 35 h.p. suffices to drive 22 plates, together with conveying and packing machinery, &c.

The roller or cylinder process is also arranged in buildings up to 100 ft. long. These contain iron framework supporting rollers about 8 in. to 9 in. in diameter and from 3 ft. to 8 ft. long. Under each cylinder is a row of burners set from $\frac{7}{8}$ in. to 4 in. apart. Scrapers are arranged between adjacent rollers. The deposit is collected in hoppers and conveyed to the end of the shed and thence to the packing section. The rollers are driven by worm gear from line shafting, in turn driven from the main shaft by chain and sprocket. One building will house up to 288 rollers with as many as 10,000 burners. The quality of the black depends upon the rate of revolution, which ranges from 1 in 15 to 1 in 45 minutes.

The output is dependent upon numerous factors. We have already noted the effect of quality of the gas. Ventilation is another factor of importance, and the buildings are usually fitted with adjustable ventilators along the ridge and at the base of the sides. Draughts must be excluded, and it is necessary in some locations to erect elaborate wind breaks to windward of the plant. The distance of the burner from the depositing surface also affects the output and needs careful adjustment to the class of gas burnt. The rate of movement of the depositing surface affects the quality more than the quantity produced. It is stated that the cooling systems originally adopted have been abandoned. The temperature in a channel-process building is from 650 deg. to 800 deg. F., about 10 in. above the channels, and that of the channels themselves from 932 deg. to 1,100 deg. F. A surface that is too cold chills the flame and less black is deposited in consequence. A decrease is also found to result if the surface becomes too hot.

This rather peculiar industry is migratory, and the plant is all of a rather crude character, capable of more or less easy transport and erection. The industry is most profitable where natural gas is cheap, and, so long as it is virtually a waste product, from the absence of domestic or industrial demands, it can be exploited satisfactorily for carbon-black. As soon as the domestic supplies are called for, the price goes up and the carbon-black industry is forced to remove to other fields. The method is not looked upon as wasteful in isolated sections where there is no present or prospective market for the gas, so long as the gasoline is reclaimed first. Owing to the high value of gasoline, it is naturally to the interest of the operator to attend to this. Legislation, however, has been introduced in several States safeguarding the gas supplies from abuse. The actual efficiency is low, amounting only to 2·5 per cent. recovery. The process is attended by enormous losses of heat, and latterly attempts have been made to utilise this in some way. It is argued that even at its worst the system is defensible, as it is the only known means of utilising isolated supplies and is preferable both to letting the gas go to waste and to plugging off the supply with the danger of flooding and loss to the well.

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

By W. NOBLE TWELVETREES, M.I.Mech.E., A.M.I.E.E., M.Soc.C.E. (France).

(*Continued from page* 229.)

Boiler-House Plant.—Apart from the coal and ash-handling appliances, and from the auxiliaries forming integral parts of the Weir Unifex closed circuit-feed system, the former already dealt with, and the latter described later, the boiler plant at present installed comprises 12 land-type marine water-tube boilers, supplied and installed by Messrs. Babcock and Wilcox, Limited, each complete with superheater, steel tube economiser and chain grate stokers. The arrangement of the boilers and their auxiliaries is shown in Figs. 63 to 65, annexed.

Additional boilers are about to be supplied for the third turbo-generator set previously mentioned, and there will be 42 boilers in all when the boiler-house has been extended to its full length. The contract for auxiliaries, including condensers, air and circulating pumps, air filters, water extraction pump, feed heaters, evaporators, Venturi meter, atmospheric relief valve, &c., was placed with the British Thomson-Houston Company, Limited, who sublet the contract for the condensers and some other auxiliaries to Messrs. G. and J. Weir, Limited, and that for the air filters to Messrs. W. Grice and Sons.

The boilers are erected in groups of three at right angles to the axis of the building, each group backing the adjacent group. The steel chimney and

Prat induced-draught plant required for each pair of back-to-back boilers were supplied by Mr. S. Utting, of Westminster. The heating surface of each unit is 5,348 sq. ft., and that of the corresponding economiser is 3,393 sq. ft., the total effective heating surface of each boiler and economiser being 8,741 sq. ft. All the boilers are designed for a working pressure of 320 lb. per square inch, and the superheaters raise the temperature of the steam to 700 deg. F. Each boiler is fitted with a pair of Babcock and Wilcox chain grate stokers, 14 ft. long by 8 ft. wide, giving a total grate area of 224 sq. ft. per boiler. The stokers have forced draught attachment, and when burning coal with a calorific value of 9,000 B.Th.U., and with the feed inlet to the economiser at a temperature of 150 deg. F., each boiler is capable of evaporating 35,000 lb. of water per hour under normal working conditions, with a maximum evaporation of 42,000 lb. of water per hour in case of need. One of the boiler units is illustrated in detail in Figs. 66 and 67, on the present page, and a view of one of the boiler banks during erection is given in Fig. 68, annexed.

Most of the boilers are fitted with enclosed-type forced draught stokers with a view to the use of low-grade fuel, but the stokers are arranged for ready conversion to induced draught conditions in connection with fuel of better quality. The remaining boilers are fitted with Babcock and Wilcox patent compartment forced draught stokers, where the application of the forced draught is confined to compartments between the chains, the ash pit being left open. Air is admitted to any portion of the grate at high velocity, by means of a distributing plate, there being three separate compartments to each grate, thus permitting variations of pressure to be made at the front, middle or end, as may be desired. This type of stoker is particularly suitable for burning low grade fuels, and can be converted to induced draught conditions when necessary. Air for the forced draught stokers is furnished by four 45-in. double inlet type fans in the basement, through a main air duct running underneath the centre of each boiler. These fans were supplied by the James Keith and Blackman Company, Limited. Each fan is capable of mantaining the air supply to three boilers, whose total normal requirements are about 54,000 cub. ft. per minute, the pressure maintained in the ash pits being 0·25 in. water gauge under normal conditions. The fans are capable of performing their normal duty when running at about 275 r.p.m. with an electrical input not exceeding 13·2 kw.

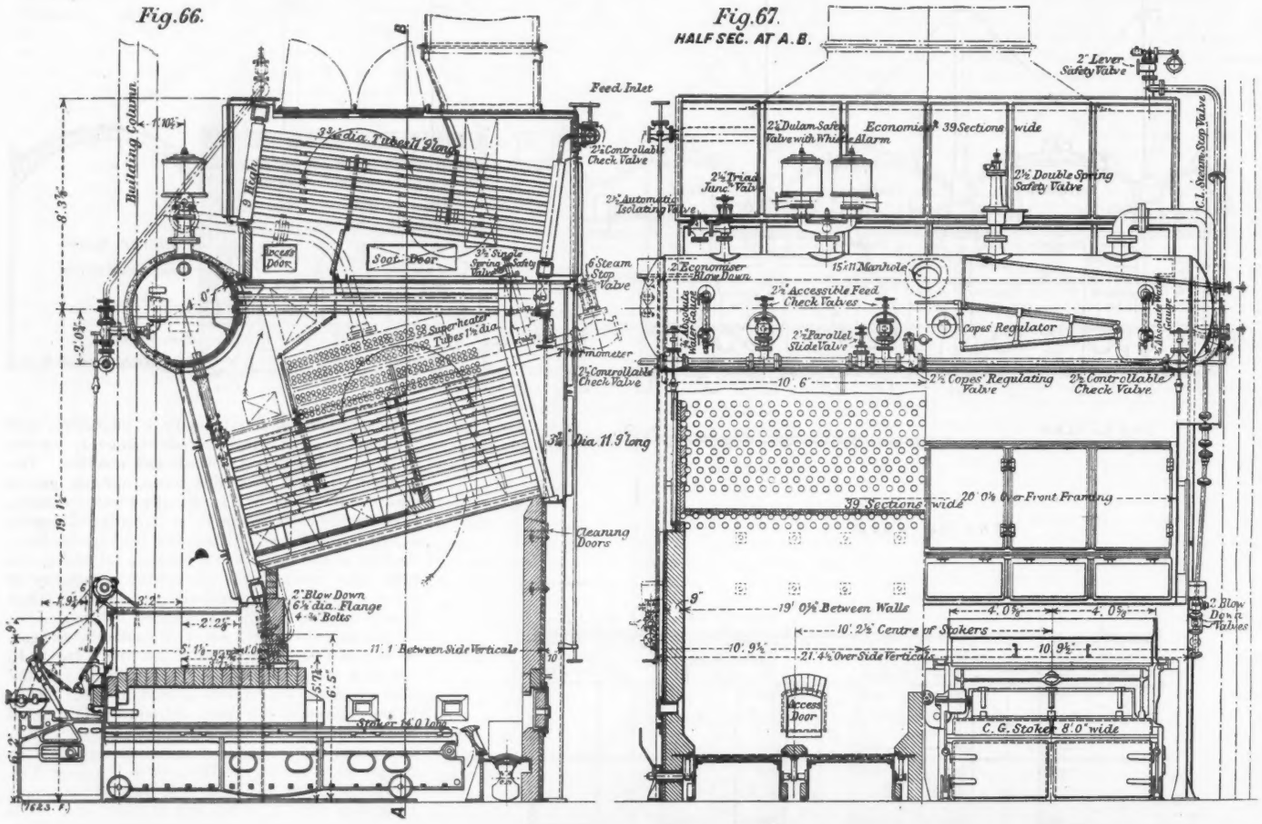


FIG. 68. BOILER ROOM.

The fuel chiefly used at the new generating station will probably consist of low calorific value slack, consisting of particles of various sizes. When discharged from an ordinary coal shoot, the particles are very unequally distributed, fine material collecting at the bottom, while the larger pieces work their way towards the top and fall on either side. To obviate this difficulty, Messrs. Babcock and Wilcox devised their travelling shoot, an example of which has been installed at the Nechells generating station. The shoot is suspended by a swivel attachment under the delivery valve from the overhead bunkers, and is free to move across the full width of the hopper supplying the stoker. The shoot is attached at the lower end to a spindle extending across the entire width of the front of the stoker, and carrying a double right and left-hand wide pitched thread engaging a corresponding sleeve

on the shoot. By the aid of this arrangement the shoot is travelled continuously to and fro' across the hopper, with the result that the coal is distributed in an even layer in a proper state of admixture, and a homogeneous firebed is secured.

Steam and Feed Pipework.—The first and second groups of boilers deliver steam through 6-in. pipes into a 12-in. main passing down between the boilers and dropping vertically into a steam separator. A similar arrangement is made for the other two groups of boilers. The separators are connected by cross-over mains where 12-in. mains branch off to the turbines in the adjoining part of the building. A thermometer is fitted on the main close to the inlet of each turbine, and a meter is provided for each of the branch pipes from the boilers, so that the steam output from the latter can be separately measured. For pipes up to and including 6-in. internal diameter, mild steel flanges are screwed and expanded on to the pipes, the flanges being riveted on in the case of the larger pipes. Branch connections are made by means of specially-tapered nozzles riveted on to the pipes. The flanges between adjoining lengths of pipe are riveted together, but where a pipe and a valve are connected, the flanges are made with spigot and socket faces and are connected by Low-Moor iron bolts, nickel rings with fine corrugations being used for the jointing surface.

The six boiler feed pumps, included in the Unifex feed system, which is dealt with later in connection with the condensing and water-cooling plant, are supplied with steam from a 3-in. auxiliary main, directly connected to each of the boilers. The pumps are situated in a separate pump room and deliver into two 8-in. mains, made for a working pressure of 375 lb. per square inch. These mains extend throughout the length of the boiler-house, with two 6-in. branch mains between the successive sets of six boilers. Each boiler can be fed from two 6-in. branch mains, these connections being again subdivided so that the feed can be taken either to the economisers or to the boilers direct.

Induced Draught Plant.—Each pair of steam boilers is equipped with a set of the Louis Prat "In-Circuit" induced-draught plant, a form of apparatus wherein the fans use a portion of the main flue gases for the purpose of draught induction. Each set is capable of dealing with the gases of combustion of two boilers consuming a total of 15,000 lb. of fuel per hour. The chimneys are of mild steel and are of the usual Prat type, but a novel feature of the Nechells installation is that each chimney is fitted with two fans, placed internally and on opposite sides of the chimney base. The chimneys are designed so that the fans operate together for all rates of steaming between normal full load and 20 per cent. overload on the boilers. Under the latter condition, the total load on each fan is 27 b.h.p., or 54 b.h.p. in all. The general arrangement of the plant is shown by the drawings reproduced as Figs. 69 to 71, on the present page.

Either of the fans running singly will deal with all loads up to the normal full load rating of the two boilers. Consequently, one fan and motor will act as a standby. The usual standby jet is also fitted, and can be operated independently, or in conjunction with either or both of the fans. Each fan is direct coupled to a 33 b.h.p. totally-enclosed pipe ventilated motor of the shunt-wound type, taking direct-current at 440 volts to 460 volts, and mounted on an extended bedplate. The fan rotor complete with motor and bedplate can be withdrawn from its casing and clear of the chimney base in about 20 minutes for inspection. Although the fans deal with the hot flue gases, water-cooled bearings usually employed in this class of work, are dispensed with. The inner bearings are provided with a Prat air-cooling device consisting of a small auxiliary fan fitted to the induced draught fan rotor—an arrangement which has given every satisfaction at the existing stations of the Birmingham Electric Supply Department.

A simple device for trapping grit forms another special feature of the plant. On reference to Fig. 71 it will be seen that the base of the chimney is partitioned horizontally, the gases from the uptakes dividing into two streams, lettered *a* and *b*, where they enter the chimney base. Stream *a*, flowing on the upper side of the partition, passes into the chimney direct, and *b* flowing on the under side of the partition passes through the fans. Experiments have shown that, owing to the low velocity only a very small proportion of grit is carried up the chimney. Before the gases enter the fan, their velocity is increased at the point A, the object being to project the heavier particles into the hopper at the base of the chimney.

Ash Handling Plant.—Fine ashes, or riddlings, from the chain grate stokers are collected in hoppers below the stokers and extending downwards into the basement, while ordinary ashes are received in hoppers immediately beneath the boilers, these hoppers being also in the basement. On this floor of the boiler house there are three 30-in. gauge tracks running longitudinally, one under each row of boilers and interconnected by means of points and curves to two tracks at the south end, whence they emerge at the foot of a twin ash hoist, discharging into a reinforced concrete ash bunker erected over the new canal arm ending near the switch-house. From the bunker ashes can be fed either into barges or railway wagons as desired.

Both sets of hoppers can be discharged directly

Fig. 69.

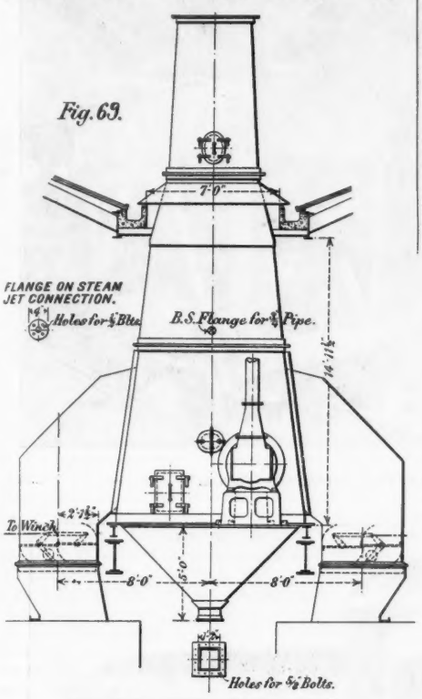


Fig. 70.

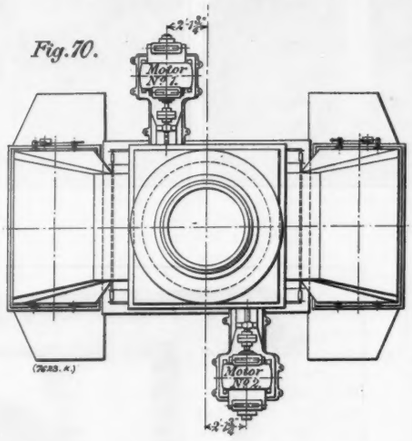


Fig. 71.

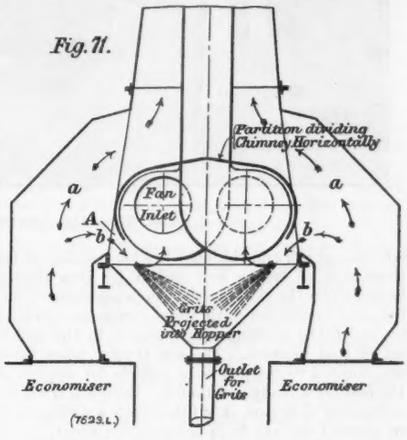


Fig. 72. SECTIONAL ELEVATION.

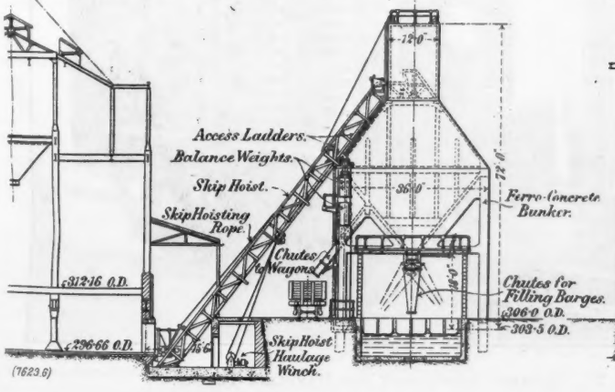


Fig. 73.

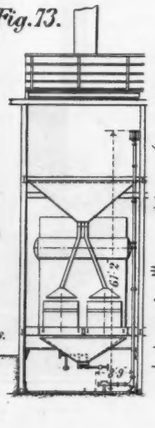
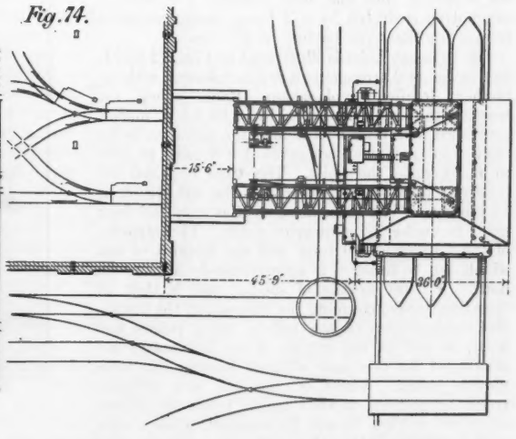


Fig. 74.



ASH-HANDLING PLANT AT THE NECHELLS POWER STATION.

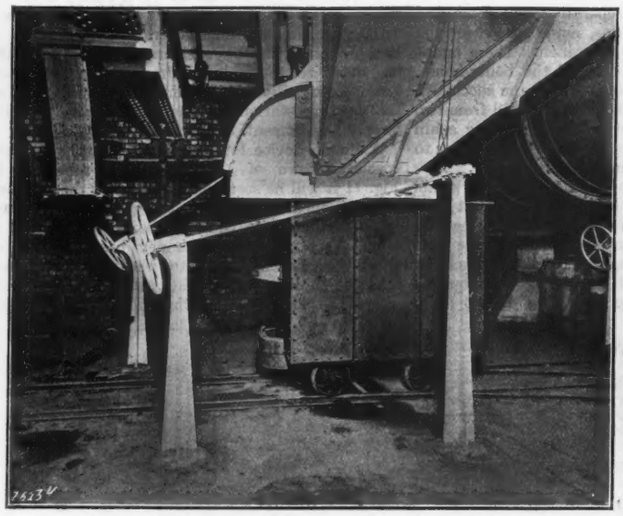


FIG. 75. ASH TRUCK.

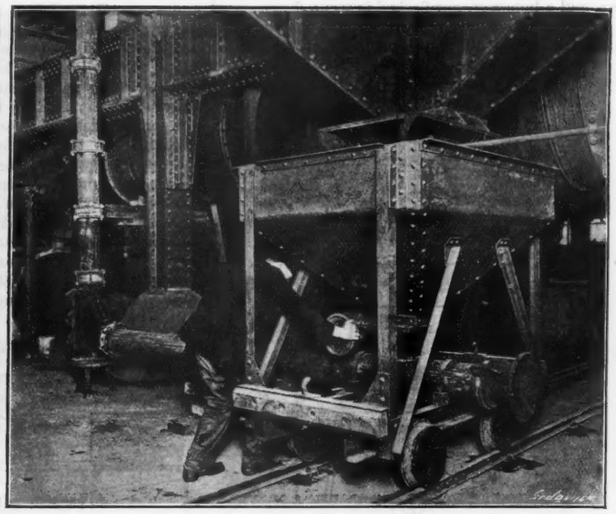


FIG. 76. RIDDLINGS TRUCK.

into special ash and riddlings trucks, running on the three sets of tracks and drawn by two electric locomotives, the riddlings trucks being shunted into line and connected with three steam-jet elevators by which the riddlings are returned to the middle set of coal bunkers. The ash trucks, when filled, are shunted to the ash hoist outside for disposal in the manner already mentioned. Each ash truck has a capacity of 2 tons, it is fitted with a sliding cover to prevent the ash from being blown about, and it fits correctly into the hoist cradle. The electric locomotive is driven by a 3 b.h.p. motor supplied from a traction type battery of 40 cells.

The twin ash hoist is illustrated in Figs. 72 to 74, and the general arrangement will be followed without further detailed explanation. Each winch for hoisting the cradle is driven by a 10 b.h.p. motor, controlled by a push button near the entrance to the cradle, so that the locomotive driver may be able to manipulate the hoist. The time required for hoisting, tipping and returning the ash truck is 1½ minutes. The ashes are cooled as they fall from truck to bunker by a spray of water. The capacity of the bunker is 300 tons, and the amount of ash which can be handled is approximately 30 tons an hour. A point worthy of special note is that all the operations of coupling and uncoupling the trucks, the manipulation of ash valves, track points and hoist, as well as the driving of the locomotive are performed by one man without leaving the locomotive cabin. Views of the ash and riddling trucks in position on their tracks below the boilers are given in Figs. 75 and 76, annexed, while a view of the electric battery locomotive is also given in Fig. 77, on the present page.

(To be continued.)

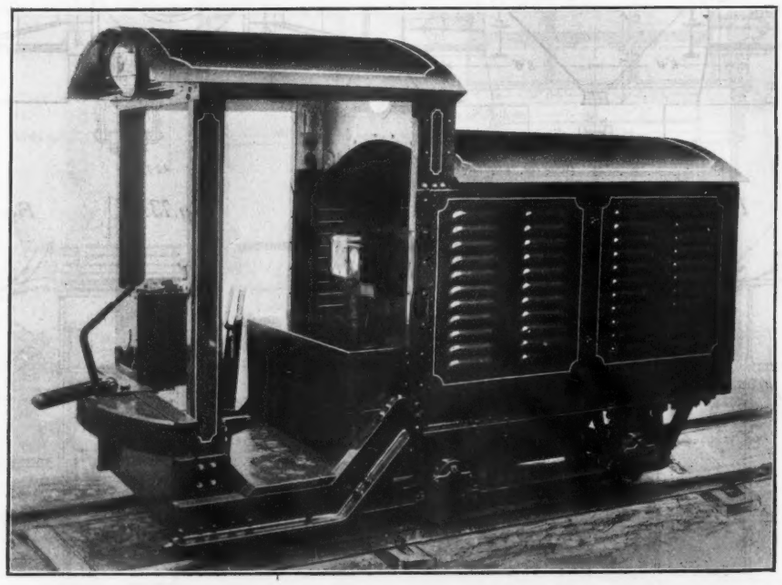


FIG. 77. BATTERY LOCOMOTIVE FOR HANDLING TRUCKS.

THE LATE DR. ING. CARL PAUL GOERZ.—The founder of the Goerz optical instrument factories, who died in Berlin last month, 69 years old, started a workshop for fine mechanics with two assistants in Berlin thirty-six years ago. Photographic appliances were his original speciality: the anastigmatic lenses which he and E. von Hoegh brought out for the improvement of instantaneous photography, made the name of the firm famous. The manufacture of other optical apparatus, and kinematographs, and of meteorological and aeronautical, and finally military instruments was later taken up, and the firm, developed into a big company, acquired a leading position in its domain. Always anxious for the welfare of his employees, Dr. Goerz was one of the first to arrange for an 8-hours' day and proper holidays for everybody. Though he himself took charge more of the commercial and technical management than of the scientific investigations, he was personally responsible for the support, frequently credited to the firm, of tropical disease studies and of various scientific expeditions. The present director of the Optischi Anstalt C. P. Goerz, A.G., of Berlin-Friedenau, is Dr. F. Weidert.

THE INDIAN FISCAL COMMISSION AND THE FUTURE OF INDUSTRY.

THE people of India have for long demanded a full inquiry into their overseas trade policy which found expression in the debate on a resolution submitted to the Imperial Legislative Council on March 21, 1916, by the Hon. Sir Ibrahim Rahimtoola, in reply to which the Government of India announced the appointment of the Indian Industrial Commission. A request was made that, in the terms of reference of this inquiry, the question of protection of industries by a tariff and the necessity for securing fiscal autonomy for India should be considered, but Sir William Clark explained, on behalf of the Government, that the question of protection was not one that could be dealt with while the Empire was at war.

Fresh emphasis was given to the importance of the fiscal question in India by the authors of the Report on Indian Constitutional Reforms, which is commonly referred to as the Montagu-Chelmsford Report, in which reference was made to the desire to find another substantial base for the Indian revenues than that of the land, and to the hopes of the educated Indians that they may have Indian-made clothes to wear and Indian-made articles to use. These desires, whatever economic fallacies may be their foundation, are well established. One statement in that report is of exceptional interest in the discussion of the question of tariff reform for India. It is "so long as the people who refuse India protection are interested in manufactures with which India might compete, Indian opinion cannot bring itself to believe that the refusal is disinterested or dictated by care for the best interests of India."

Another stage was reached in the development of the policy of fiscal autonomy in the deliberations of the Joint Select Committee on the Government of India Bill, the report on which was presented on November 17, 1919. In that document the statement was made that "A satisfactory solution of the question can only be guaranteed by the grant of liberty to the Government of India to devise those tariff arrangements which seem best fitted to India's needs as an integral portion of the British Empire.

It cannot be guaranteed by statute without limiting the ultimate power of Parliament to control the administration of India, and without limiting the power of veto which rests in the Crown; and neither of these limitations finds a place in any of the statutes of the British Empire. It can only, therefore, be assured by the acknowledgment of a convention. Whatever be the right fiscal system for India, for the needs of her consumers, as well as for her manufacturers, it is quite clear that she should have the same liberty to consider her interests as Great Britain, Australia, New Zealand, Canada and South Africa."

On February 23, 1921, a resolution was moved by the Hon. Mr. Lalubhai Samaldas, in the Council of State, and agreed to, praying "that the Government of India be granted full fiscal autonomy, subject to the provisions of the Government of India Act." That resolution was forwarded to the Secretary of State, and the Cabinet, despite the strong opposition from Lancashire, accepted the principle recommended in their report by the Joint Committee on the Government of India Bill.

On October 7, 1921, a resolution was issued stating that the Government of India, with the approval of His Majesty's Secretary of State, had decided to appoint a Fiscal Commission, consisting of 12 members, of which the Hon. Sir Ibrahim Rahimtoola, was president, Mr. J. M. Keynes was vice-president, and Mr. H. G. Haig, of the Indian Civil Service, was secretary. The terms of reference to the Commission were "to examine with reference to all the interests concerned, the tariff policy of the Government of India, including the question of the desirability of adopting the principle of Imperial Preference, and to make recommendations." All the members of the Commission, with the exception of Mr. Keynes, were resident in India. Owing to his work in connection with the Genoa Conference and other circumstances, Mr. Keynes was unable to join the Commission, and the investigations were conducted without his assistance. A questionnaire was drafted by the members of the Commission and various associations and individuals were invited to submit replies in writing. Publicity was given to the contents of the questionnaire, and a general invitation was issued to all interested, although not otherwise invited, to express their views. Written statements, to the number of 281, were submitted to the Commission, and the authors of these, to the number of 142, were asked to give evidence orally. With the facts and suggestions put before them in this way, the Commissioners had a wealth of evidence on which to come to their conclusions and base their report, which was recently published by His Majesty's Stationery Office, at a price of 6*s.* net.

The state of Indian finance may be judged from the fact that in 1921, further large changes had to be made in the existing tariffs to produce an additional revenue of eight crores of rupees. The general rate of duty was raised from 7½ per cent. to 11 per cent., the excise remaining as before at 3½ per cent., but the special exemption which the cotton mills had enjoyed in respect of imports of cotton machinery and stores was withdrawn. Other duties were increased and new ones instituted. Under such conditions, the Commission began its deliberations, but while they were sitting in 1922, the financial embarrassments of the Government were again so considerable that further far-reaching changes in the tariff system were necessary. The general rate of duty was raised from 11 per cent. to 15 per cent., but the duty on cotton piece goods remained at 11 per cent. and the excise at 3½ per cent. At the same time the duty on iron and steel and on railway materials was raised from 2½ per cent. to 10 per cent.

The Commission reported "That the industrial development of India has not been commensurate with the size of the country, its population, and its natural resources, and that a considerable development of Indian industries would be very much to the advantage of the country as a whole." In order to secure the achievement of a more satisfactory condition, the Commission recommended that the Government of India adopt a policy of Protection, to be applied with discrimination in the selection of the industries for protection and in the amount to be afforded, so as to make the inevitable burden on the community as light as may be consistent with the due development of industry. The founding of a Tariff Board was advised, for the purpose of dealing with claims for protection on the three grounds: That the industry possesses certain natural advantages; that without this fiscal aid it would not develop at all, or only slowly and that it would have to face world-competition without protection. Raw materials and machinery, the Commissioners thought, should be admitted free of duty, and that semi-manufactured goods, used in Indian industries, should only be taxed as lightly as possible. The adequate protection of industries essential for national defence, for which the conditions in India are favourable, was deemed imperative. It was recommended that export duties, except for purely revenue purposes, should be abolished, with the exception of duties on food-grains, which might be resorted to temporarily to restrict export. The Commissioners were very emphatic in their disapproval of any general system of Imperial Preference, but suggested a policy of preferential duties on a limited number of commodities which should be referred to the Indian Legislature after examination by the Tariff Board. Should this proposal be adopted it was suggested that its application be governed by the principle of not granting any preference without the approval of the Legislature, and then only when the privilege granted would not diminish the protection required by Indian industries, or involve any appreciable economic loss to India. Any possible preferences, it was suggested, should be granted to the United Kingdom as a free gift, but to all the other parts of the Empire only by mutually advantageous agreements. The Commissioners suggested the removal of the existing cotton excise duty, and that the Government start with a "clean slate" and regulate their policy solely in the interests of their country. A number of subsidiary recommendations were made regarding the removal of shipping rebates and unfair advantages, such as dumping, depreciated exchanges and bounty-fed imports from abroad. An important suggestion regarding the provision of a supply of skilled labour related to the giving of a more practical bias to primary education, providing increased facilities for the training of apprentices and the founding of organisations to increase the mobility of labour. One of the most outstanding recommendations of the Commissioners was, "That no obstacles be raised to the free inflow of foreign capital, but that Government monopolies or concessions should be granted only to companies incorporated and registered in India, with rupee capital and a reasonable proportion of Indian directors."

The proposals were put forward not so much to satisfy the insistent demands of the educated Indians, but also with the intention of expediting an increased industrial development in the country. The reasons for their suggestion can only be understood after a complete and thorough examination of the present economic position of India. The predominant position of agriculture is the outstanding feature in the situation, for, on work of that class, no less than 224,000,000 people, or 72 per cent. of the total population shown in the 1911 census, depend for their livelihood. India has also two great textile industries in cotton and jute. In the year 1919, which is the latest for which statistics are available, there were 277 cotton spinning and weaving mills, employing 306,310 persons, in addition to 140,786 engaged in 1940 cotton ginning, cleaning and pressing work. There were 76 jute mills, employing 276,079 persons, as well as 211 jute press works, providing work for an additional 33,316. After these in importance, come the railway workshops which make use of the services of an eighth of a million people. Engineering and iron and steel works engage the activities of appreciable numbers of workers, but to a much less extent than the other industries cited.

In India there are large coal deposits, though the fuel is not of a very high quality, and the potentialities of an extensive hydroelectric development show the possibilities of an ample power supply for industry. There is also room for extension, in the utilisation of Indian oil fuel. One limitation to progress is the great dearth of skilled labour. Another but gradually diminishing one, is the difficulty of finding Indian capital. The old habits of hoarding and investing capital only in ornaments are gradually dying, under the influence of the new ideas bred of education, increased banking facilities and a new enthusiasm for the employment of capital in industrial concerns.

The industrial development of India will undoubtedly increase the production of wealth and enrich the country generally, will reduce the excessive dependence on agriculture, and produce an increased and more economic employment of labour. Many of the witnesses who appeared before the Commission looked on industrial development to provide a solution to the problem of agricultural poverty and a remedy for the periodical scourge of famine. A secondary effect of the possible increase of wealth created by industry, is the effect it will have on the public revenues.

That there are disadvantages in this suggested change no one would doubt. The possible consequences of the aggregation of population in large towns are not all for the benefit of the people, and the periods of poverty and unemployment, which seem inseparable from industrial work, may create conditions formerly unknown to the Indian people. The older industrial nations have learned by bitter experience the disadvantages of these conditions, and have tried to remedy them, and it may be possible for India to profit from this. The natural feelings and habits of the people may favour the development of industry in comparatively small towns, but a factor of great moment in this matter is the magnitude of the railway rates.

The Indian population have seen other countries, such as Japan, develop their manufactures to a remarkable degree under a system of protection, and believe they are capable of doing the same. They also believe, that if India were allowed her freedom to decide her policy in her own interests, she would soon regain her economic prosperity. The Indian people can point to numerous precedents for the adoption of protection. Even the industrial foundation of England, like those of other countries, were laid under a system of high protection. Since the European War, departures have been made from the free trade policy of the homeland, by the duty of 33⅓ per cent. on motor cars, which has a protective effect, the safeguarding of Industries Act, and the recent removal of the excise duty on sugar to encourage the nascent sugar beet industry.

After an extensive examination of all the conditions, the Commission recommended that India should adopt a policy of protection, not only because of the people's demands but because they thought it essential in the earlier stages of the development of industry. In this action, they follow John Stuart Mill when he said "The only case in which, on mere principles of political economy, protecting duties can be defensible, is when they are imposed temporarily (especially in a young and rising nation) in hopes of naturalising a foreign industry, in itself perfectly suitable to the circumstances of the country." The system affords an example of what Mill calls "the least inconvenient mode in which a nation can tax itself for such an experiment." The Commissioners stated as their belief that the fiscal change suggested would be beneficial to the United Kingdom, as well as to India, because the increased prosperity of India through her manufacture of simple articles will create an increased demand for the high-class and well-finished goods from Britain. They conclude their report by saying, "We are convinced that the path of liberality is the path of wisdom and that a more prosperous India, will mean a more prosperous Britain."

L.C.C. SCIENCE AND ART SCHOLARSHIPS.—The London County Council is prepared to consider applications for the following scholarships from British subjects, provided their parents or guardians live in the County of London:—1. Intermediate technical or art scholarships; 2. Senior scholarships in science and technology or art and artistic crafts; 3. Free places at the Imperial College of Science and Technology; 4. An "Archibald Dawnay" scholarship in civil engineering. Detailed particulars may be obtained from the Education Officer (Technology Branch) at the County Hall, Westminster Bridge, S.E.1, or may be seen in the *Scholarships Handbook*, obtainable from Messrs. P. S. King and Son, Limited, 2 and 4, Great Smith-street, Westminster, S.W., price 3*d.* (by post 4½*d.*).

EXHIBITS AT THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM.

Fig. 33.

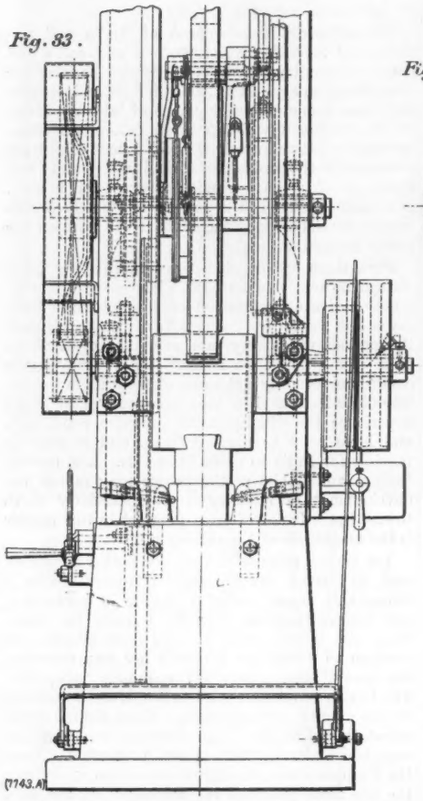


Fig. 34.

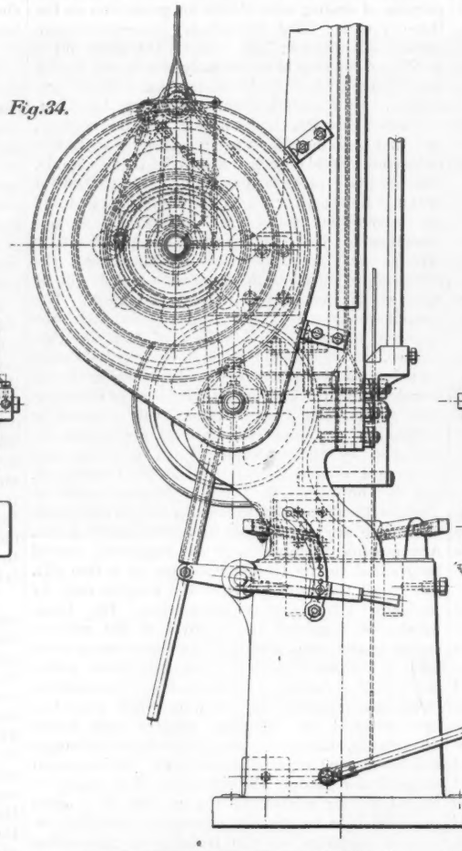
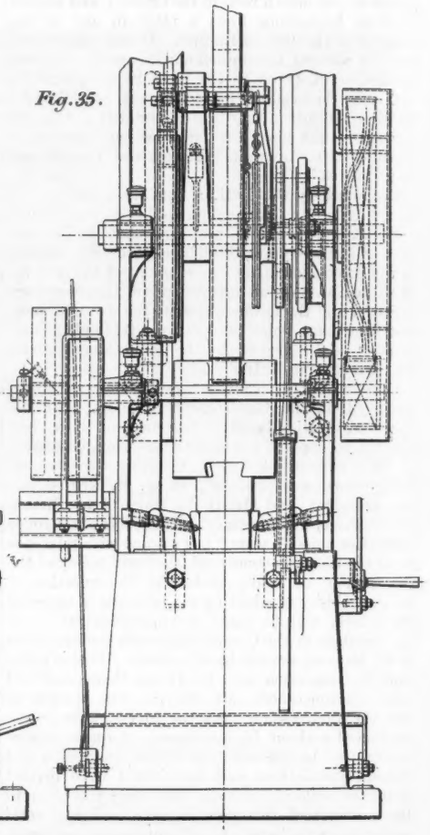


Fig. 35.

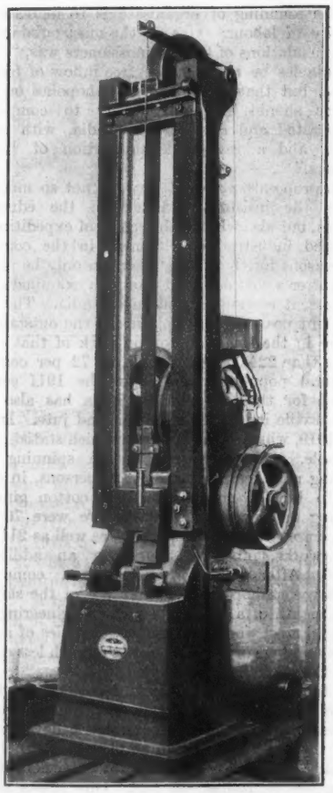


THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM.

(*Concluded from page* 263.)

MESSRS. ALLDAYS AND ONIONS, LIMITED, of Great-Western Works, Birmingham, exhibited various kinds of machinery for forge and smithy work, including an oil-fired furnace and an air compressor. We illustrate in Figs. 33 to 36 on this page, an automatic drop-hammer which was to be seen on their stand. The driving shaft and gear are fitted low down at the back so that the pull of the belt does not affect the stability of the machine. The clutch for actuating the lifter is of the spring-band type acting on a drum keyed to the lighting shaft. One end of the steel band is fastened to the lifter arm, the other end is attached to a crank actuated by clutch lever. A hand-controlling lever is attached by a link to a slotted disc which has a cam. When the control lever is depressed the disc is turned round and engages the cam with a roller on the clutch lever. The incline of the cam moves the end of the control lever until the roller rests in the hollow at the top of the incline, when a steel band grips the friction drum and the whole of the clutch parts are carried round with it until the end of the slot comes into contact with an adjustable stop pin.

With the control lever depressed and held by a locking screw on the quadrant, the hammer goes on working automatically and lifts to a height corresponding to the position occupied by the stop pin. The tup returns automatically after each fall to the top of its lift ready to deliver the next blow. The hammer can be arranged to strike from 40 to 100 blows per minute according to the type of work being operated on. In addition to the automatic working of the hammer a light relay clutch is fitted for hand or foot control. This is very useful for setting dies or for striking intermittent blows. Either arrangement can be used without alteration to the machine. The hammer and tup can be quietly raised to any position or lowered gently to the dies or when working automatically the falling weight can be arrested at any point of its fall.



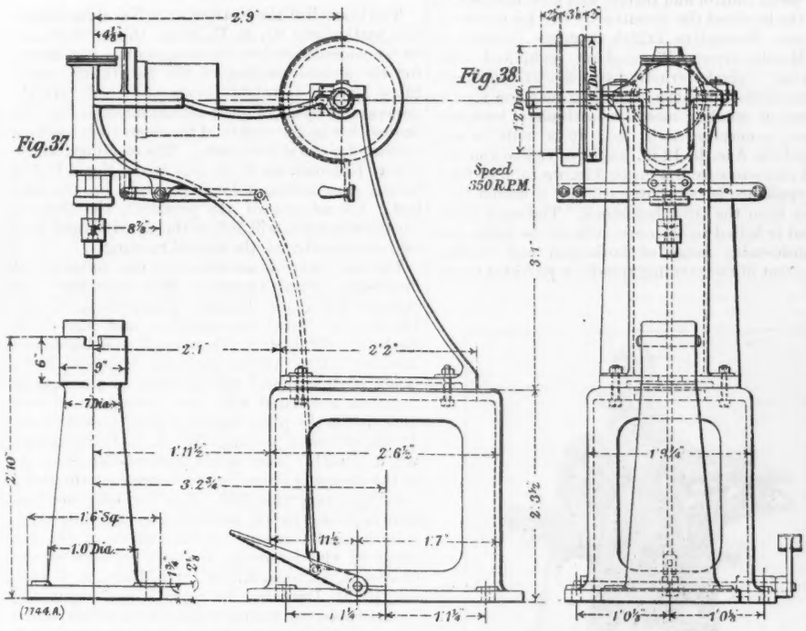
FIGS. 33 TO 36. 2-CWT. DROP HAMMER; MESSRS. ALLDAYS AND ONIONS, LTD., BIRMINGHAM.

Whilst the machine is at work the height of the lift can be quickly adjusted from a few inches to the full stroke. Both hand and foot control are fitted. Hammers of this type are made with falling weights varying from 2 cwt. to 10 cwt. and can be supplied with drops up to 7 ft.

A power-driven pneumatic planishing hammer for coppersmiths and sheet metal workers, which was shown on their stand is illustrated in Figs. 37 to 39, on page 297. The hammer head is caused to reciprocate by the pressure and vacuum alternately formed in the horizontal cylinder at the head of the framing, by the motion of a piston driven by a connecting rod from the belt pulley shaft. The hammer may be controlled either by the hand or the foot of the operator and the force of the blow varied with certainty and ease. Either a heavy or light blow may be given up to within an inch of the top of the stroke, so that work may vary in height without necessitating any alteration to the tools or to the machine. The hammer illustrated has a 20-lb. head with a 10-in. stroke, and makes 350 strokes per minute. Four other sizes are made, the smallest having a 5-lb. head with 4-in. stroke giving 530 blows per minute, and the largest having a 50-lb. head with a 14-in. stroke and making 300 blows per minute. The hammers may be stopped instantly and are under perfect control, the tups remaining at the top of the stroke when at rest.

Messrs. Lucas Furnaces, Limited, of 45, Newhall-street, Birmingham, showed a series of gas-fired furnaces for the hardening and heat-treatment of small articles generally. The general appearance of these furnaces will be understood from Fig. 40, page 297, while Figs. 41 to 43 illustrate the construction. The outlet of the waste gases from the interior of the furnace is by means of a port in the furnace floor immediately inside the door. When the door is opened any cold air entering is drawn down this port by the draught, and is thus prevented from cooling the furnace or oxidising the contents. The abstraction of heat from the waste gases by the air used for combustion is so complete that the

EXHIBITS AT THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM.



FIGS. 37 TO 39. POWER-DRIVEN PNEUMATIC PLANISHING HAMMER; MESSRS. ALLDAYS AND ONIONS, LIMITED, BIRMINGHAM.

FIG. 39.

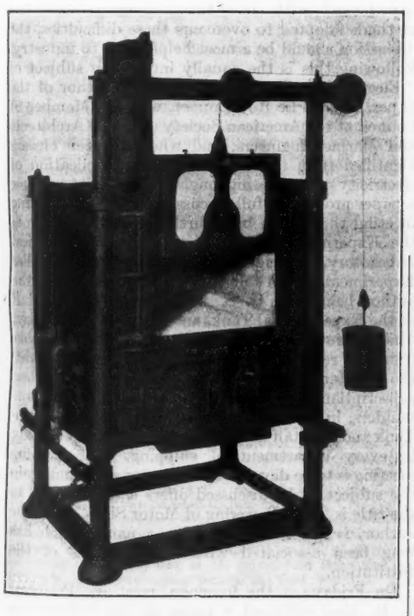
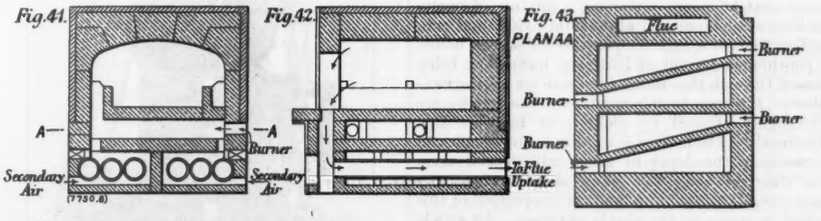


FIG. 40.



FIGS. 40 TO 43. GAS-FIRED HARDENING FURNACE; MESSRS. LUCAS FURNACES, LTD., BIRMINGHAM.

hand could be comfortably held over the top of the waste gas pipe through which the gases discharge, although this was only a very few feet from the furnace proper. The complete mixing of the hot air with the gas ensures very perfect combustion, so that the efficiency of the furnaces is high whilst the heating remarkably even throughout the interior. To avoid any possible trouble due to small articles falling down the waste gas port when being placed in, or removed from, the furnace, a cast-iron dead-plate is provided which can be pushed over the port to completely close it at such times. Should any article, however, fall down the port it can be recovered in a moment by opening a door beneath.

Messrs. Frys (London), Limited, of 46, Upper Thames-street, London, E.C. 4, showed an attractive little 4-in. screw-cutting gap-lathe suitable for garage work or amateurs' requirements. The bed, which is 30 in. long, is of a strong box-section, with a central leading screw, to drive which change-wheels and reversing gear are provided. The lathe is supplied either as a bench lathe only, or with a tray and stand so that it is independent of any bench. It will take work 8 in. diameter over the bed or 10½ in. diameter in the gap, up to a length of 15 in. between centres. The headstock has a hollow spindle and three-speed cone pulley and the tail-stock can be set over for taper turning. The compound slide rest is fitted throughout with adjustable strips for taking up wear and the top slide can be swivelled to any angle. Altogether it is a well-made and useful tool. All ordinary fittings are supplied with the lathe, the net weight of which is 200 lb. inclusive of the countershaft. Messrs. Frys, Limited, are also showing a variety of hardened hack-saw blades and a range of Whitworth taps and dies of British manufacture, the quality of which is said to be at least equal to that of the best imported articles while the price is considerably lower.

Sheet metal-working machinery of various kinds was exhibited on the stand of Mr. Walter Frost, of Eagle Iron Works, Rochdale, a firm who have specialised in this line for many years. Among the new machines was a set of bending rolls with which it was not only possible to do ordinary circular bending, but sharp right-angled bends could also be produced. This particular machine had rolls 2 in. diameter and 37 in. long. On it rectangular tubes could be formed, or tubes with some curved corners and others square, and the edges could be turned at right angles projecting either inwards or outwards where they meet. Right-angle bends were made by placing a piece of angle-iron between the feed rolls and bending the sheet round its external angle by a vertical motion of the adjustable roll. By swinging the top roll sideways the work could be slipped off over the end of the roll. Another interesting machine was one for seaming, corrugating, indenting or rolling tubes or cylinders. The work was slipped on a mandrel and the seam traversed by a suitable roller driven to and fro' on slides along the machine by an endless sprocket chain. Each side of the chain geared with an idle sprocket wheel on the head carrying the roller, and by the motion of a small lever either sprocket wheel could be locked at will, the direction of motion of the head being of course determined by which sprocket was locked. The machine was driven by a single belt running constantly in the same direction, and with it one girl could groove and flatten one hundred and twenty 36-in. lengths of tube in an hour.

The most diversified display of machine tools was that on the stand of Messrs. Charles Purden, Limited, of Lancaster-street, Birmingham, where lathes, milling machines, drilling machines, &c., were to be seen. Among the lathes a 6½-in. brass finisher's lathe with self-contained reversing motion may be mentioned. The reversing countershaft is fitted on a bench carried from the back of the lathe-bed and is operated by foot pedals. A compound slide rest with swivelling top slide, as well as an ordinary hand rest, is provided, and a double cutting-off slide, operated by a lever is also fitted. A light vertical milling machine with belt-driven spindle was another useful tool on the stand. This had a table with a working surface of 17¾ in. by 5 in., with longitudinal traverse of 9½ in. and 3½ in. cross traverse. Power-feed with automatic stop was provided. The table had a vertical adjustment of 8¼ in., and the hardened and ground spindle of the machine was hollow and made suitable to take draw-in collets.

The Selson Engineering Company, Limited, of

83 to 85, Queen Victoria-street, London, E.C. 4, exhibited a large selection of the chucks and other apparatus which go to make up the smaller equipment of a tool room or machine shop. Especially noticeable was a machine vice for holding awkward-shaped articles. The work was indented with three centre-punch marks on a line scribed parallel to the surface to be machined. One jaw of the vice carried two transversely sliding heads, each with a horizontally-projecting steel centre. The other jaw carried a similar head, also adjustable transversely. The vice could thus be closed with the three steel points gripping the article by the centre punch marks, and when tightened up the article was held rigidly enough for any ordinary machining process. The method appeared quite suitable for holding even comparatively heavy pieces, and when one considers the forces which an ordinary lathe centre will stand when large forgings are being turned, there appears no reason to doubt that the principle of holding work in a vice by means of point-contact is capable of extensive application. It is also worth noting that the strain on the work may be relieved for the finishing cut without fear of it slipping, and furthermore, the three suspension points may be used as reference points in subsequent vice or jig operations. Other articles shown by the Selson Company included an adjustable bit for cutting circular holes in sheet metal by means of an ordinary carpenter's brace and a well-made dividing head of simple design.

The Scarab Oil Burning Company, Limited, of Carlton House, Regent-street, London, S.W.1, showed samples of work to illustrate the efficacy of a new process for preventing the oxidisation of metals at high temperatures. The process, which is called "calorising," consists in placing the articles in an airtight retort containing a mixture of finely-divided aluminium and aluminium oxide, and subjecting them to a high temperature for several hours, a continuous current of hydrogen meanwhile being passed through the retort to ensure an inert atmosphere. Previous to this treatment, the articles are thoroughly cleaned by pickling or sand-blasting. The result of the process is to form a surface alloy of aluminium, the depth of which will depend upon the time allowed. The outer skin is practically pure metallic aluminium, and the proportion of this metal decreases as the depth increases. An article treated in the manner described is said to entirely resist oxidation up to a temperature of about 1,800° F. or 1,000° C. The surface is rough and somewhat like that of cement. The metal cannot be hammered or bent cold, and cannot be machined after treatment, except by grinding. Calorising is not an adequate protection against rusting under ordinary conditions, but it appears thoroughly effective in preventing the scaling of iron and steel at furnace temperatures. On the stand of the Scarab Company were pieces of iron of which parts were calorised and parts left in the normal condition. After lengthy exposure to furnace conditions, the treated parts appeared quite unchanged, whereas the other parts were blistered up and thoroughly spoilt by a thick coating of blue scale. It is claimed that the life of articles can be increased from five to thirty times by the treatment, which has been successfully applied to pyrometer tubes, carbonising and annealing boxes, furnace stay nuts, air pre-heating tubes, &c. Besides iron and steel, articles of nickel and copper can be treated by the same process, and to a less extent, cast-iron.

The machine illustrated in Fig. 44, is known as the Frost "Multi-Worker," and has recently been designed to save the time usually spent in changing heads on various kinds of machines. On the upper part of the standard is mounted a four-armed turret, each arm of which carries a pair of roller tools. The live shaft of each pair of tools terminates at its inner end in a bevel wheel. The driving shaft also terminates in a bevel wheel, but as the turret is mounted eccentrically with this shaft, one pair of tools only is in gear at any time, the other three being stationary. After he has finished with one pair, the operator can swing the turret through 90 deg. and bring the next pair into position for use and so on. The machine can be used for cutting, edging, flattening, beading, flanging and numerous other operations, and is especially useful where a sequence of operations has to be performed. It can be adapted to be worked either by hand or power. The illustration shows it arranged for a power drive, with pedal control and reverse and stop motions, so that the hands of the operator are free for the work.

Messrs. Productive British Grinders, Limited, of 38, Moseley-street, Birmingham, exhibited their "Fremo" cylinder grinding attachment, which can be mounted on a lathe or milling machine for the purpose of grinding motor car cylinders, bushings, pistons, connecting rods, &c. It is built to suit lathes from 5 in. to 12 in. height of centre and will grind diameters from 2 in. to 5 in. up to 9 in. long. The appliance is self-contained, and is driven by a carrier from the lathe headstock. The work to be ground is bolted to the cross slide of the lathe, and a considerable range of horizontal and vertical movement of the grinding spindle is provided for by

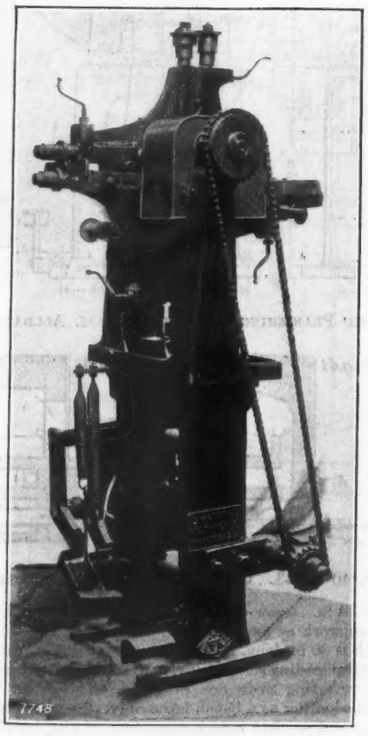


FIG. 44. MULTIPLE-HEAD METAL-WORKING MACHINE; MR. WALTER FROST, ROCHDALE.

a special eccentric mounting. The spindle runs in double spherical ball bearings fitted with dustproof caps, and altogether the appliance is well designed and should be a really useful tool in repair shops, garages and other workshops where there is not sufficient work for a special grinding machine.

Among the many firms with whose exhibits lack of space prevents us dealing in detail are Messrs. John Thompson (Wolverhampton), Limited, Wolverhampton, who showed full-sized sections of water-tube and Lancashire boilers, Messrs. C. D. Monninger, Limited, 59, Farringdon-road, E.C. 1, and the Dominion Machinery Company, Limited, of Halifax, both of whom had fine displays of wood-working machinery; The Rapid Cobalt Company, Limited, Mount Pleasant, Liverpool, who demonstrated the exceptionally high cutting speeds of their special twist drills; Messrs. Gibbons Brothers, Limited, Dudley, who showed furnaces and furnace machinery; The Delta Metal Company, Limited, of Birmingham, whose display of forged and extruded bars and sections of yellow metal was really striking, and last but not least the Association of Drop Forgers and Stampers, nearly a score of whose component firms occupied between them 27 stands with drop-forgings of every description. The Fair ended on Friday last, March 2.

THE INSTITUTION OF NAVAL ARCHITECTS.

THE Council of the Institution of Naval Architects, and particularly Mr. R. W. Dana, the secretary, are to be congratulated on the programme, just issued, for the annual meeting of the Institution, which takes place a fortnight hence. Not only are the papers on subjects of great topical interest, but they deal with a larger variety of problems than has been the case for one or two years. The meetings, which, it may be noted, are to be held at the Royal United Service Institution, Whitehall, begin on the 21st inst.; the address of the president, the Duke of Northumberland, will follow the usual formal business associated with the annual meeting.

The first paper is an attractive one, namely, "A Proposed Aircraft-Carrying Mail Steamer," the authors being Sir Eustace d'Eyncourt, K.C.B., Director of Naval Construction, and Mr. J. H. Narbeth. Sir John E. Thornycroft and Lieutenant Bremner follow with a paper on "Coastal Motor Boats in War-time," and in view of the difficult problems associated with the attainment of very high speeds the paper ought to be of great interest. At the afternoon meeting, Mr. A. C. F. Henderson, will deal with "Some of the Present-Day Problems in the Design of Ships," giving scope for a discussion covering a very wide field. The Thursday meetings, from beginning to end, promise to be very interesting. "Mechanical Gearing" is the subject of the first paper of the forenoon, and the authors are Sir Charles A. Parsons, K.C.B., and Messrs. S. S. Cook and H. M. Duncan. No topic is exciting greater interest amongst marine engineers than this, and if the individual members of the Institution will recognise their duty to the profession collectively, and therefore frankly give data as to the difficulties experienced with mechanical gearing, and the methods adopted to overcome these difficulties, the discussion should be a most helpful one to industry. Following this is the equally interesting subject of "Electric Ship Propulsion," and the author of the paper, Mr. W. Le Roy Emmet, who is a Member of Council of the American Society of Naval Architects and Marine Engineers, and who has been closely identified from the outset with the application of electricity on board ship, ought to be able to produce a paper prompting full discussion. For the evening meeting there is to be a further contribution from the Experimental Tank of the National Physical Laboratory, dealing with "Model Screw Propeller Experiments with Mercantile Ship Forms," the author being Mr. G. S. Baker, chief of the staff at the Experimental Tank, and Mr. W. C. S. Wigley. This continuance of the disclosure of the profitable results of research work at the Tank ought to assist the secretary of the Institution in securing further subscriptions from shipowners as well as shipbuilders, in order to increase the possibilities of the Tank and the staff helping towards a higher economy in every department of shipping. The evening meeting is to be devoted to the motor ship, and again the subject to be discussed offers a wide range, as the title is "The Powering of Motor Ships," and the author, is Mr. K. C. Barnaby, a name which has long been associated with the activities of the Institution.

On Friday, at the forenoon meeting, Professor T. B. Abell will read a paper on the "Behaviour of Stiffened Thin Plating under Water Pressure," to be followed by one by Dr. J. Montgomerie, of Lloyd's Register, on "Further Experiments on Large-Size Riveted Joints," while the third paper will be by Mr. John Anderson, the subject being "The Influence of Form upon the Stability and Propulsion of Passenger Ships." At the evening meeting on Friday, Mr. W. Thompson, also of Lloyd's will deal with the "Effect of Variations in Loading on Longitudinal Structural Stresses in Ships," followed by one by Mr. E. V. Telfer, on "Graphical Trim Calculation and a Trim Nomogram." It is further interesting to note that the summer meeting of the Institution is to be held in Holland early in September.

SWISS SAMPLE FAIR.—The seventh Swiss Sample Fair is to be held at Basle from April 14 to 24. Full particulars concerning this can be obtained from the Commercial Division, Swiss Legation, 32, Queen Anne-street, W. 1.

"THE INTERNAL-COMBUSTION LOCOMOTIVE."

TO THE EDITOR OF ENGINEERING.

SIR,—Internal-combustion locomotives can be divided into four classes:—1. Locomotives with mechanical, electrical, pneumatic or other transmission, which is used through the whole of the speed range of the engine, *i.e.*, automobile system 2. Locomotives which have the above systems of transmission, but use it only at one part of the speed range and drive solidly above this point. 3. Locomotives which drive direct or "solidly" at all and throughout all parts of speed range. 4. Locomotives which have a regenerative system applied to the prime mover and use it as a secondary fluid at normal speed, but make it the primary fluid at starting, these may or may not drive direct.

On the face of it, the internal-combustion engine as we know it in normal type, demands a transmission system, but since we have already in the prime mover an efficiency such as to give us a consumption of a quarter the consumption of the steam locomotive, we can afford to put in a reasonably efficient form of transmission, provided it does not entail excessive weight and maintenance. The type of engine developed in submarine practice will form the basis of locomotive work, and it will be necessary to work with high mean effective pressures and solid injection to keep down weight, if the weight is not below 50 lb. per brake horse-power it is not of much use.

Reliability of engine is most essential and must be accompanied by reliability of transmission, and each must bear the other out in its capacity for overloads. The transmission purports to give us constant speed of prime mover, reduction of weight, uni-directional rotation of engine, employment of multi-cylinders of reliable diameter, with provision for cutting out cylinders permanently on light loads, the whole transmission to be performed in an efficient and reliable manner without any redundant gear. Except for one or two particular systems, the electric transmission seems to be heavy and introduces too much gear. For example, a locomotive to haul 200 tons up 1 in 100 at 10 miles per hour, requires approximately 400 horse-power at prime mover. Weights come out approximately as follows:—

	T.	c.	q.
Heavy oil engine at 48 lb. per horse-power	8	12	0
Generator at 60 lb. per horse-power ...	11	0	0
Motors	10	0	0
Electric gear	3	0	0
Total extras	30	0	0
	62	12	0

A corresponding steam locomotive would weigh, 35 tons for engine plus 20 tons for tender, a total of 55 tons.

One difference is that in the thermo-electric locomotive the 62 tons 12 cwts. is all adhesive weight, or 100 per cent. adhesive, in the steam locomotive we have only probably 27 tons adhesive or less than 50 per cent. available for adhesion.

Thus, we have greater capacity on the part of the former for notching or momentary overloads, but on the part of the latter for sustained overloads. With improvements in both engine and generator design, it ought to be possible to reduce weights and also increase simplicity, and another form of the thermo-electric locomotive is extremely favourable, *i.e.*, the double-unit construction, in which we have two locomotives which can be used individually at their maximum efficient loading or together, thus keeping always at the conditions of lowest fuel consumption. The electric transmission has decided advantages for rail-car work, in that the whole of the weight can be used for adhesion, but requires controls at both ends.

Hydraulic and pneumatic transmission do not seem sufficiently developed to promise advantages over electric systems, except in weight, and sometimes in cost, but the latter has been called into play in one form in the proposal of Burns and in the early Sulzer-Diesel locomotive and will yet be used in future.

The writer, however, would propose a three-cylinder direct-driving locomotive; the cylinders would not perform any charging function, but would themselves be charged with (*a*) gas or (*b*) liquid-fuel from the (*a*) charging and scavenging pump, (*b*) fuel pump. The engine could be charged at any point in the compression stroke and could be run on a constant-volume cycle until the engines warmed up and then would function on the constant-pressure cycle. Through a special feature of the design, a rich mixture could be located near the ignition plugs and its combustion controlled so as to obviate any blowing off of cylinder heads or broken crankpins.

The air consumption would be reduced, since only the centre-cylinder crank would have to provide for starting torque produced from the pressure of air on the piston of the scavenging cylinder. The temperature and working conditions of the three working cylinders would not be affected by the expansion of starting air and the centre cylinder would drive the scavenging piston direct, relieving the crankshaft of any undue torque.

Change of fuel would not affect the above engine as the compression pressure is sufficient to cause combustion of any known fuel by the processes already commonly used in the Hird, Steinbecker and similar engines.

In conclusion, I should like to state that no locomotive firm can hope to build any type of internal-combustion engine, unless they use the experience of practical internal-combustion engineers with experience of heavy-oil and high-power internal-combustion engines; the experience of existing locomotive staff with motor-car type engines cannot be of use and will only hinder progress. It will be better to take men and train them than attempt to unlearn men whose ideas are of the motor-cycle school.

I am, Yours truly,

C. S. DARLING, Whit. Sc.

SOCIETY OF GLASS TECHNOLOGY.

THE President, Professor H. E. S. Turner, D.Sc., presided at the meeting of the Society of Glass Technology, held in Armstrong College, Newcastle-on-Tyne, on Wednesday, February 21.

The first paper on the agenda was "Organising for Production from Pot Furnaces," by W. W. Warren, A.M.Inst.C.E., A.M.I.E.E. (manager of Messrs. Lemington Glass Works, Limited). The subject of this paper was approached with the aid of experience gained at the Lemington Works, where methods for producing electric lamp bulbs from pot furnaces were modelled on those which obtained in German and Dutch glass works. It was admitted that the manufacture of bulbs was considered low in the appraisal of those who spoke of the art of glass making, yet it was a business which, because the article made was light, magnified possible sources of waste—waste of time, waste of metal. In order to work out a pot of metal in a given time, small gathers must be numerous and follow quickly on one another. The waste of metal in the making of light articles generally bore a larger proportion to the saleable product than was the case with heavy articles. These considerations demanded a close control of both system and workmanship.

Comparing the present works practice at Lemington with that of 1918, when the output of hand-made bulbs was approximately similar in number and weight, there were now only 20 pots in commission, as against the 70 pots in 1918. This intensifying of production per pot had effected an enormous saving of coal, and in a lesser degree, of pots, and of auxiliary labour. In fact, fuel costs were less than in pre-war times. It had to be remembered, however, that the furnaces that had been shut down were direct coal fired furnaces, leaving the gas furnaces only in operation. In 1918, four men worked at a pot, where there were now six; and the time table system of founding by night and working by day was not so perfect as it was now.

Production on a satisfactory basis could never be achieved unless the furnace design would permit of adequate temperature for rapid melting, perfect and elastic control of temperature, and uniform distribution of heat. The function of a furnace was to melt glass. The time occupied to work out pots, cooling off pots beyond the "plaining stage" and charging with batch and cullet, should be regarded as operations, albeit necessary, which lowered melting efficiency. Metal that was too hot, or that was not quite plain at the commencement of the day, might easily affect the daily output to the extent of 15 per cent. For most purposes circular gas furnaces, either regenerative or recuperative, were to be preferred to those of rectangular shape. They provided around the pots working spaces, the boundary lines of which diverged outwards and furnished facilities for a larger number of men, unless the inefficient method of working out alternate pots was adopted. The semi-circular or "D" shaped furnaces developed at Lemington, while not efficient in fuel consumption on account of their large radiation surfaces, had an appreciable range of temperature control above that necessary for melting.

The heat stored in the wall representing the straight line of the "D" was considerable and made for uniform heat conditions. The maximum temperature of the furnaces when using covered pots was 1,500 deg. C., and when using open pots 1,400 deg. C. During the working period the temperature was lowered to 1,100 deg. C. inside the pot. Among the advantages of working to a time table in the matter of founding and working during definite periods were:—(*a*) a responsibility devolved on the producer and furnace men to have metal ready in time for their co-workers; (*b*) mixing, filling pots and all labour subsidiary to glass making worked smoothly in an appointed groove. The importance of checking the output of pots should be realised, and figures taken out daily to inform the management of variations in pot efficiency.

The reducing effect on costs of bringing idle plant into commission and thereby increasing production was appreciated and needed no comment: but the similar effect as the result of operating more efficiently running plant was striking and worth closer inspection. The elimination of waste might be turned to advantage in meeting increasing demand, in operating a minimum number of furnaces and in creating a demand by cutting prices.

In view of the practical demonstration at Lemington of the possibility of ladling either sand or lime soda glasses from pots in which the glass melted into a tank, and the successful operation of the Westlake bulb blowing machine in conjunction therewith, it would appear reasonable to expect to derive the full advantages of such practice if introduced into the domain of hand-made ware. The disadvantages were those attached to shift work and to ladling glass. The tank would probably throw small stones, and blisters might be prevalent. There would be the further disadvantage common to all large units of plant when they went out for repairs, viz., the cessation temporarily of a large output. Further, the large unit was not so elastic in coping with a variable demand.

To enlist the co-operation of the glass-blower or the worker in glass, was the first step in any scheme devised for intensifying production. Customs were hard to break down, but they gave in response to appeals made to intelligence. Propaganda, incessant rumour talk of what was going to be done, and why; foremen's meetings, these all maintained enthusiasm and fostered the progressive spirit. Informal talks with the men's committee, with a blackboard for illustrating points and explaining figures, rarely failed to convince that foreign competitors' methods and prices were a challenge to business. But if there were rewards at the end of the production programme, the men must share, particularly if one programme was going to be followed by another and another. An efficiency method which worked well in the U.S.A. was that of setting up temporary ideal standards of efficiency. When these were reached others were set up, with the lure of the attainable. The lure rests in the standards having been shown to be possible.

Mr. Warren concluded by thanking the directors of Messrs. The General Electric Company, Limited, for their permission to use the information contained in the paper.

During the forenoon, a party of members of the Society visited the glass works at Lemington and saw in actual operation the scheme outlined by Mr. Warren.

The other two papers on the agenda were:—(*a*) "The Effect of Boric Oxide on the Melting and Working of Glass," by F. S. Hoskin, B.Sc., and Professor H. E. S. Turner, D.Sc., and "Some Physical Properties of Boric Oxide-Containing Glasses," by Violet Dimbleby, B.Sc., S. English, M.Sc. and Professor H. E. S. Turner, D.Sc.

These two papers were taken together and presented by Professor Turner, who pointed out that the boric oxide glasses were of the greatest importance commercially. Although boric oxide had been used as a constituent of glass for at least a century, it assumed a much greater importance as the result of the researches of German workers at Jena about forty years ago. In the last few years borcailicate glasses had been used to an increasing degree, the new British chemical glass, the well-known American Pyrex glass for chemical ware and cooking ware, and various forms of illuminating glasses, all containing it. He proceeded to give an outline of investigations, designed to lay down a foundation of facts concerning the glasses.

Turning to a discussion of the properties of the glasses, Professor Turner said that there were some striking results to be announced. Although the addition of boric oxide to a silicate glass brought them a marked increase in the durability, this beneficial effect only held good up to a certain point, the maximum benefit for the glass with 20 per cent. of soda being obtained at 11 per cent. to 12 per cent. of boric oxide. Thereafter the glass became less durable, until, when 35 per cent. to 40 per cent. was present, the glass readily dissolved in water. Again, the reduction in thermal expansion reached a maximum effect at about 20 per cent. of boric oxide in both series of glasses. After that the expansion increased. Hence it followed that the usefulness of boric oxide was limited, and further experiments of the heat-resisting glasses must lie in other directions than the employment of boric oxide. Similar inversions in other properties, namely, in the annealing temperature, the density, and refractive index, had also been found at the Department of Glass Technology, Sheffield University.

The President intimated that the next meeting would be held in Birmingham on March 21.

CONTRACTS.—It is announced that Sir. W. G. Armstrong Whitworth and Co., Limited, have secured orders for 37 heavy main line locomotives; of these 20 are for the Indian State Railways and 17 for the East Indian Railway. These locomotives which are intended for goods traffic, are of the 0-6-0 superheated type, with six-wheeled tenders for a gauge of 5 ft. 6 in. They will be built at the firm's Scotswood Works, at Newcastle-on-Tyne.—The English Electric Company have recently obtained an order for a reversing electrical drive for the 30-in. finishing rail mill at Messrs. Guest, Keen and Nettlefolds' Dowlais Works. The mill motor will be capable of giving a maximum power of 8,600 h.p. at a speed of 60 r.p.m. to 120 r.p.m.

THE LATE MR. WILLIAM M. ALSTON.—After an active life of service in the interests of the Clyde Navigation Trustees, Mr. William M. Alston died in his 79th year, on February 20, at his residence in Glasgow. He entered the service of the Trust in 1863, and retired in 1918, during the last eighteen years of which period he held the post of engineer-in-chief. In his long association with the development of the navigation of the Clyde, he had the privilege of witnessing the effects of the services rendered by the Trust, in the progress and welfare of Glasgow and its commerce, and had the satisfaction of knowing that his great share in the work was appreciated by his fellow citizens. Mr. Alston superintended the construction of Plantation Quay, and was resident engineer on the work of making the Queen's Dock between 1873 and 1880. In the following twenty years he was associated with his chief, the late Mr. Deas, in the strenuous parliamentary work of that period and in designing the important harbour improvements of Prince's Dock and the No. 3 graving dock. In 1900 he was raised to the position of engineer-in-chief, and his careful and thorough work was shown throughout all the progressive development in the following years. Rothesay Dock, Shieldhall Wharf, Merklands Quay, Yorkhill Quay and the Meadowside Granary, stand as testimony to the value of his service. The river channel was widened and deepened under his direction. The accommodation of the quayside he extended until it reached to 11 miles length. A zealous and devoted servant of the Clyde Navigation with a sound professional judgment in all matters relating to harbour work. Mr. Alston was the happy possessor of a most courteous nature which won for him the affection of all who were associated with him.

THE SEDGWICK PLATE-BENDING MACHINE.

PLATE-BENDING machines in general are of the guillotine type in which a blade with a lower edge of vee form forces the plate into a gapped recess, or die resting on the bed of the machine. As the width of this vee is usually such that it only extends an inch or so on each side of the blade, the ultimate purchase or leverage is very limited. A variety of change parts are also necessary to produce bends of different form. An interesting departure from this method of bending has been made in the Sedgwick patent machine, which is built by the Sedgwick Machine Company, Limited, of 10, Arthur-street, King William-street, London, whose works are situated at 36, West Ferry-road, Millwall. It is claimed that, owing to the better application of the leverage in the Sedgwick machine, it requires considerably less power than the guillotine type, and while of ample strength is some 50 per cent. lighter than guillotine machines of the same capacity. The Sedgwick machine will produce a wide range of work of varying angles and corner radii without the use of any change parts whatever.

The Sedgwick machine is illustrated in the annexed figures, Figs. 1 to 3 giving a front elevation, plan and end view partly in section, while Figs. 4 to 6 are general views. The main feature of the construction is a pair of rocking tables which fold upward and bend the plate, which is held in position by an upper beam which is adjustable for position. The rocking tables are hinged about the centre line of the machine. Their arrangement will probably best be understood from Figs. 5 and 6, which show them in an upward position. It will be clear that as the tables swing upwards in the way shown, they will bend any plate which is lying on them, since it will be held down by the central beam at the point of bending. The tables when swung upward form the vee in which the plate is bent, and owing to their width give a bending leverage factor some 18 times greater than is obtained with a fixed recess. The amount of movement of the tables can be regulated at will so that a plate may be bent to any angle desired. The radius of the corner formed is determined by the position of the adjustable beam which lies above the plate. This beam is shown in cross-section in the left-hand half of Fig. 3. Its vertical position is adjusted by the screws with cross-handles which can be seen in most of the figures. The radius of the corner produced increases as the beam is raised. This effect will be obvious, since, as the force required to bend the plate increases with the sharpness of the bend, the plate takes the line of least resistance and produces a regular curve of which the knife edge of the beam is a point on the circumference, and the two tables form tangents.

The tables are operated by a number of toothed quadrants which are attached to them and are driven by pinions carried on shafts running along either side of the machine. The arrangement is shown in Figs. 1 to 3. The pinion shafts are operated from a belt pulley through a train of gears which is shown in the figures. It may be noted that the power required to drive the machine is small, so that a drive can usually be obtained from the shop shafting without difficulty. The size of machine capable of bending plates up to 6 ft. long by ¼ in. thick, takes 3½ h.p. The belt-pulley drive is arranged for a quick return, and an automatic cut-off is provided so that the machine will throw-out when the plate has been bent to the angle desired. This cut-off operates on the driving belt. It is shown in Fig. 4, from which its action will be understood without further explanation. In order to facilitate the removal of plates after bending, one of the end housings is pivoted and arranged to swing as shown in Fig. 6. This allows the bent plate to be removed endwise. Another feature which may be mentioned is that the machine illustrated in Fig. 4 has a slotted beam. This arrangement is introduced in order that trays may be edged on four sides. It may finally be pointed out that the machines operate entirely without shock and that no very heavy foundations are required.

3½-CUBIC YARD STEAM SHOVEL.

A REMARKABLY interesting collection of machinery is being employed in connection with the important harbour construction which is being carried out at Takoradi in the Gold Coast Colony. This machinery includes the three largest steam shovels ever built in this country, in addition to four other excavators of special type, sixty 16-cub. yard automatic air-dumping cars, 100 hand dumping cars, 54 light tip wagons, forty 25-ton railway wagons, 18 locomotives of various types, &c. The purpose of this article is to describe the 3½-cub. yard shovels, but in order to explain the work required from these machines, it will be well briefly to indicate the general nature of the Takoradi works.

The littoral of the Gold Coast Colony is remarkably deficient in natural harbours or deep bays of any kind, and at the present time steamers visiting the principal ports, Accra and Seccondee, have to lie some distance from the shore and receive, or deliver, cargo to small craft. Surf boats capable of carrying about 1¾ tons each are mainly used, although a certain amount of lighter transhipment takes place, more expecially at Seccondee. The small harbour at Seccondee connects with the more important railway of the colony, as was explained in our article on the Gold Coast Colony which appeared in our issue of December 29 last, but the harbour is badly silted, and in any case does not offer the deep-water facilities which are necessary if the colony is to develop in the way that is desirable.

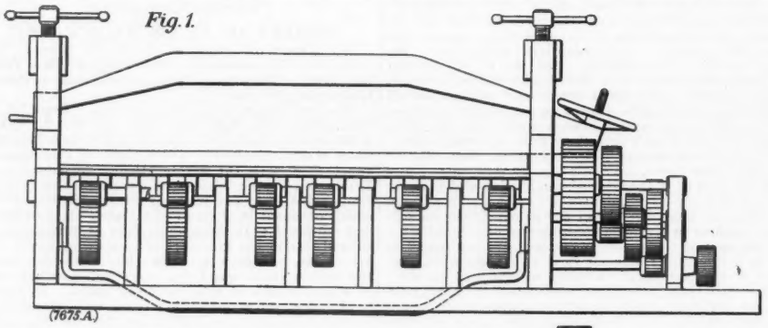
With a view to the better opening out of the country, the Crown Agents for the Colonies in 1919, instructed Messrs. Stewart and McDonnell, consulting and constructional engineers, of 6 and 7, Cowley-street, Westminster, to survey the coast with the view to the formation of a deep-water harbour. Messrs. Stewart and McDonnell proposed a scheme for a port at Takoradi, which is about five miles south-west of Seccondee and consequently may be connected up with the Seccondee Coomassie Railway without difficulty. This scheme proposed a series of tidal basins and piers protected by a breakwater at a total cost of some 5,000,000*l*. In view of financial conditions, this scheme was modified to the extent that the cost was reduced to 1,600,000*l*. This modified scheme is now in hand, and involves an outer curved breakwater some 7,500 ft. long, forming the eastern boundary to a large deep-water sheltered area. The basin will be further protected by a second straight breakwater, about 3,000 ft. long, lying to the north-west of the outer structure. Quay space and storage room will be provided in connection with the scheme, special provision being made for handling manganese ore, which is one of the important exports of the country.

The coast formation in the neighbourhood of the new harbour is sandstone rock and the breakwaters will be built practically directly on this formation. The breakwater will be of the rubble type with the smaller material in the centre and faced with large pieces. The material will be a hard granite, and it is hoped that sufficient large pieces will be obtained from the quarry to obviate any necessity for concrete facing blocks. The whole of the works are being carried out by Messrs. Stewart and McDonnell, and it is in connection with the quarrying of the granite for the breakwater that the three large steam shovels will mainly be employed. Suitable material has been found at a site along the railway, and the material will be brought to the harbour along the new line which connects Takoradi with the Seccondee-Coomassie Railway. The Gold Coast Railways are of 3-ft. 6-in. gauge, and the fact that these large machines have had to be built by Messrs. Ruston and Hornsby, Ltd., of Lincoln, to travel on such a gauge, adds to the interest of their design.

THE SEDGWICK PLATE-BENDING MACHINE.

CONSTRUCTED BY THE SEDGWICK MACHINE COMPANY, LIMITED, ENGINEERS, LONDON.

Fig. 1.



(7675.A)

Fig. 2.

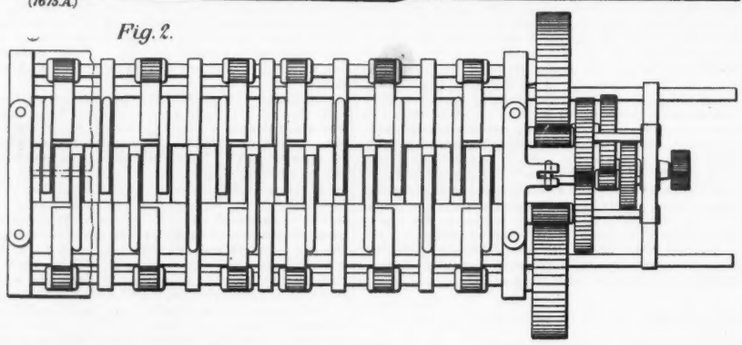
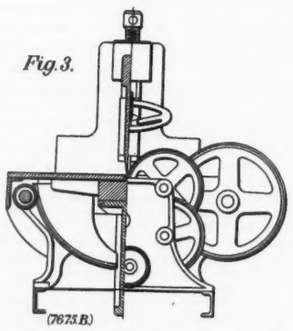


Fig. 3.



(7675.B)

One of the 3½-cub. yard steam shovels is illustrated in some detail in Figs. 1 to 9 on Plate XXI, while a general view of the machine in the builders' shops is given to Fig. 10, on page 304. As will be gathered, it follows the general lines of earlier shovels by the same builders, but is naturally heavier and more powerful to cope with the extended duty. Special arrangements have also had to be made to ensure proper stability for the machine while at work, and yet at the same time to allow it to travel over the 3-ft. 6-in. gauge railways. The main frame is built up from four 20-in. by 7½-in. rolled-steel joists connected by various cross-members. At the front end, immediately over the front bogie, there is a cast-steel bolster casting, which extends upwards between the frame members and tongues, into the underside of the A frame casting. These castings are held together by large through bolts while they are each provided with ledges to fit against the frame members. The centre post casting extends from the front of the frame to the A frame casting and a cast-steel beam is fitted to take the back tie-bar from the A frame. These arrangements will be followed from the figures on Plate XXI. As will be noted from Figs. 1 and 9, the front corners of the framing are cut-off at 45 deg. This is to allow the bucket to deal with large stones which may roll near the front bogie.

The bogies are of the standard arch bar type, and have wheels 30-in. in diameter arranged to run on the 3-ft. 6-in. gauge. The journals are 5 in. by 9 in. with cast-steel axle boxes. In order that the bogies may resist lateral loading, large collars are formed on the axles, and the top arch bar works in guides. A telescopic joint is also arranged between the bolster and spring plank. Brakes are fitted to the rear bogie only and may be operated either by steam or hand. Taxoradi couplers are fitted to conform with the regulations of the Gold Coast Railways, while the buffer at

THE SEDGWICK PLATE-BENDING MACHINE.

CONSTRUCTED BY THE SEDGWICK MACHINE COMPANY, LIMITED, ENGINEERS, LONDON.

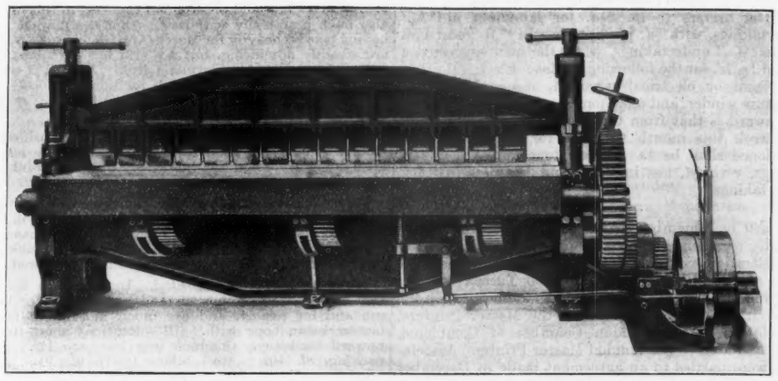


FIG. 4. FRONT VIEW WITH TABLES IN LOWER POSITION.

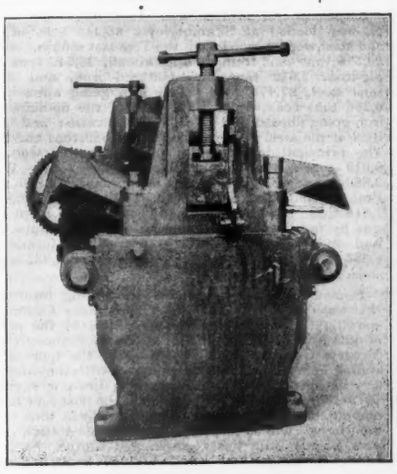


FIG. 5. END VIEW WITH TABLES RAISED.

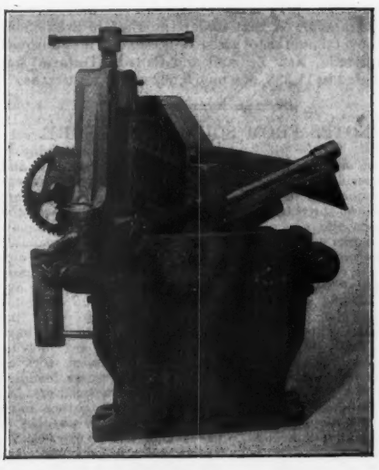


FIG. 6. HOUSING SWUNG OUTWARD FOR REMOVAL OF BENT PLATE.

the digging end of the machine is fitted so that it can be easily detached. To stabilise the machine while digging, jack arms are fitted; these are illustrated in Fig. 3, and may clearly be seen in the general view given in Fig. 10 on page 304. These arms are of the swinging type, with cast-steel struts and mild-steel tension members. By disconnecting the side braces and tension links, these arms may be swung to one side. Owing to the size of the machine, however, even in this position they will not clear the loading gauge, and if it is desired that the shovel should travel on the railway, the side braces, tension links and brackets and jack arms and brackets have to be removed. They are made detachable for this purpose.

The jib is of the combination oak and steel type. It is 30 ft. 3 in. long from the heel to the centre of the upper sheave, and is built up of two parallel timbers armoured inside and out. There are heavy steel top and bottom bars and reinforcing angles run along the lower outer sides of the jib. An upper casting carries the sheave pin and acts as a separator and tie between the jib members. It butts against the ends of the timbers and is secured to the plates. At the lower end of the jib there is a cast-steel swing circle on which the swinging ropes work. This swing circle is bolted to the trunnion which swings on the base plate pintle. The trunnion is provided with a heavy cast-iron bushing for the pintle-bearing and is arranged with sockets to take the jib feet. Adjustable side braces, anchored to the swing circle, are provided to hold the jib in place and take swinging strains, while diagonal tie-bars extend from the side anchor points to the bottom of the trunnion casting.

The A frame to the upper end of which the jib tie-rods are connected, consists of two 6-in. by 6-in. solid billet members attached to the A frame bedplate casting by fitted pins. The frame head is a steel casting with cast sockets to receive the legs which are attached by means of a pin and heavy clamps bolted to lugs on the casting. The back guy is an eye-bar which is attached to lugs on the A frame casting by means of a pin, and is attached at the other end to the cast-steel beam forming a cross member of the main frame and already referred to. The jib ties attach to a steel swivel, working on the top of the A frame and provided with a cast-iron bush. The A frame as a whole represents a carefully-considered design from the point of view of the loads coming on it. All the lines of load intersect at a point and all stresses other than direct tension and compression are eliminated. The various features we have mentioned in connection with the A frame and jib are shown in Figs. 2 and 10.

The shovel is provided with three operating engines, and a main hoisting engine which is also used for travelling, a swinging engine and a thrust engine. The hoisting engine operates the 22-in. diameter steel hoisting drum through a machine-cut single reduction gear as is clearly shown in Figs. 8 and 9. It has two horizontal cylinders, 12-in. bore and 15-in. stroke, and is fitted with Stephenson link motion reversing gear. The hoisting drum is fitted with a lowering brake race at one end, and a clutch race at the other. Both races are fitted on spigots to ensure concentricity, and bolts taking the drum are fitted. The brake race is specially designed from the point of view of allowing expansion when it heats up. Both the brake and clutch bands are lined with Ferodo fibre and are adjustable. The brake is operated by pedal, but a steam cylinder is fitted for the operation of the clutch. This is of 6-in. bore with 4-in. stroke and is fitted to one of the drum-shaft bearings. The arrangement is shown in detail in Figs. 4 to 7 on Plate XXI, from which it will be understood without further explanation. The drum-shaft with its fittings is illustrated in Fig. 11 on the page 304. The drum is fitted with phosphor-bronze bearings and runs free on the shaft when lowering. It is, however, possible to lower the bucket without disconnecting the hoisting friction or using the hoisting brake since the main regulator valve of the engine, which is of the piston type, allows the cylinders to be put in communication with the exhaust. As will be seen from Figs. 1 and 10, the main hoist operates through a chain which wraps on the hoisting drum. The guide sheaves and arrangement of the purchase will be seen from Fig. 2.

The swinging engine is situated between the cylinders of the hoisting engine, and is best seen in Figs. 8 and 9. It has two cylinders cast together and bolted to a one-piece cast-steel bedplate which contains the bored guides and crankshaft bearings. Direct valve motion is fitted which eliminates all rocker gear and the engine is controlled both for speed and direction of rotation by a central valve fitted in an overhead valve-box. The engine drives the swinging drum through a machine-cut double-reduction gear. This drum, which is 27 in. in diam., is grooved with a double thread to take the 1⅛-in. diameter steel swinging ropes. As will be seen from Fig. 8, there are two of these ropes working in parallel. They are carried round guide pulleys, which can be seen in Fig. 9, in order that they may embrace the greatest possible length of circumference of the swing circle. The swinging drum is illustrated in Fig. 12, on page 304.

The arm which carries the bucket is composed of two oak side timbers with steel top, bottom and side bars. The side bars are riveted and the top and bottom bars are bolted on. Two steel racks shrouded to the pitch line, are bolted to the lower side and engage with the gearing carried near the centre of the jib and which can be seen in Figs. 2 and 10. This gear is driven by an engine carried on the upper side of the jib, so that the operation of the engine racks the arm in or out. As will be clear from Fig. 10, the arm is divided up the centre to clear the main chain, but below the end of the rack where this clearance is not required, a timber deadwood is fitted and secured by through bolts. At the front end of the arm, heavy steel castings are provided for the attachment of the bucket. The thrusting or racking engine has cylinders 8 in. diameter by 8-in. stroke, and is generally similar in design to the swinging engine being controlled both for speed and direction by a single valve. The engine pinions are steel castings with teeth cut from the solid. These gear with the spur wheels shown in the figures, which are steel castings with the teeth machined from the solid. These wheels are carried by a 3 per cent. nickel-steel shaft, which also carries the racking pinions, these being 0·65 per cent. carbon steel castings with the teeth heavily shrouded. The shaft is made square at the seatings of the gear wheels and pinions to allow of easy removal. The racks are made from 0·45 per cent. carbon steel. A yoke block on which the arm works is a steel casting, swinging on phosphor-bronze bushes. A large steel slide plate is secured to the yoke by heavy straight bolts passing through the cap.

The bucket is of 3½-cub. yards capacity. Its front face consists of a single piece of manganese steel, and is fitted with four teeth, which have mild-steel shanks fitted with renewable manganese steel points. All castings connected with the bucket are of steel. As already stated, the shovels are intended to work in a granite quarry, and the material is of a nature such that it cannot be dug directly. It will be broken up by blasting and the broken material will then be dealt with by the shovels. For use in this connection, to supply power to drills a steam-driven air-compressor is fitted to the shovel. The compressor, which was manufactured by the Westinghouse Brake & Saxby Signal Company, Limited, has a piston displacement of 50 cub. ft. to 60 cub. ft. of free air per minute and discharges at a pressure of 80 lb. to 100 lb. per square inch. A further auxiliary is fitted in the shape of a 1-kw. electric lighting set which supplies current at 110 volts. Two large flood lights are fitted on the jib, one to show the bottom of the excavation and the other to illuminate the discharging point. Lights are also fitted inside the house to allow the machinery to be operated or repaired during the hours of darkness.

The machine is traversed by the main hoisting engine, which acts through a spur-wheel carried at the end of the drum-shaft, and which can be seen in Figs. 2, 8 and 9. This wheel, which is thrown in and out of operation by a dog clutch, gears with another spur-wheel carried by a cross-shaft running below the main frame. This shaft carries chain pinions, which drive chains connecting to pinions on the bogie axles, as shown in Fig. 2. Both the front and rear bogies are driven in this way, and the two axles of the front bogie are positively driven by a subsidiary chain. The chains are of the pin and bar type, while the sprocket wheels on the axles are made on halves for ease of fitting and removal. The boiler, which is fitted to the machine, is of the locomotive type, 50 in. in diameter and 16 ft. 6 in. long. It has 109 2-in. tubes each 9 ft. 8 in. long. The firebox is 4 ft. 2 in. long by 4 ft. 3 in. wide. A cinder-sifter is fitted in the smokebox to keep it clear of cinders, which are drawn through the tubes when

the machine is working fast. The ashpan is of steel, with a damper underneath, which can be operated from the firing platform. A feed pump and injector are fitted in connection with the boiler. There is also a feed heater. The water tanks, which are placed on each side of the boiler, have a capacity of 1,700 gallons. They are made from Armco iron and are galvanised inside and out, while the inside is also coated with bitumastic solution. The boiler and machinery are covered by a house, built of rolled sections and with roof and sides of Armco iron. The roof is lined with tongued and grooved boards with an air-space of 3 in. between the boards and the roof. The sides are hinged at the top, so that they can swing out to form sunshades.

INDUSTRIAL NOTES.

WE give below some abstracts from an article in a recent issue of *L'Echo de la Bourse*, Brussels, which refute, in the case of Belgium, the statements made in *Le Génie Civil*, with which we dealt on page 277 *ante*. The Belgian journal states that Belgian workmen go to France in large numbers for work because, on the evidence of authorities who are independent both of the employers and trade unions, in French establishments they work as long hours as they like, they earn as much as they care to earn and they escape the worries of the trade unions. The Belgian operative leaves his country since he is not allowed to give his employer the one or two extra hours which national economics require, and which the employer is ready to pay for generously, to the great benefit of the man's household budget; the Belgian laws and trade unions, however, act as an insuperable bar. He therefore crosses the frontier and thereby regains his liberty. The Belgian *Revue du Travail*, an official publication, itself confirms the facts that in France the working hours are longer, and the trade unions allow more freedom to the operatives.

Another instance of British trade union intolerance is afforded by the fact that notices of their intention to cease work in a fortnight were handed in last Monday on behalf of 18,000 miners in Glamorganshire. The trouble began at two collieries of the district, where 800 men struck work because six men, members of a new, rival union, said to be the Mechanical Workers' Union, refused to resign from that union and to rejoin the Miners' Federation.

In the course of the interview which the Executive of the Miners' Federation had with the Prime Minister last week, Mr. F. Hodges gave the following figures of excess on the average wages of all mine workers compared with pre-war: Scotland, 37·62 per cent. in excess; Northumberland, 41·84 per cent.; Durham, 48 per cent.; South Wales and Monmouthshire, 39·5 per cent.; Eastern area, 52 per cent.; Lancashire and Cheshire, 44·5 per cent.; North Wales, 37·3 per cent.; Cleveland, 55·5 per cent.; Bristol, 65·4 per cent.; Forest of Dean, 45·3 per cent.; Somerset, 44·3 per cent.; the whole of Great Britain 45·5 per cent. The Prime Minister quoted to the delegation the rates of wages actually earned now, and supplied to him by the Masters' Federation. For adult workers in the mines, those of 21 years and upwards, taking full-timers, 81 per cent. earned between 40*s.* and 90*s.*, or, to give it more accurately, 9 per cent. were between 30*s.* and 40*s.*, 47 per cent. were between 40*s.* and 60*s.*, 34 per cent. between 60*s.* and 90*s.*, and 9 per cent. 90*s.* and upwards. Mr. F. Hodges disputed these figures. On the other hand, the mine owners have since stated that throughout the whole period of the wages agreement, the owners in certain districts have worked continuously at a loss since July, 1921, and as regards the industry as a whole, at no point have the owners received the percentage of profits relative to wages which is provided in the 1921 agreement. The facts are that the mine worker is at the present time obtaining higher earnings than the workpeople engaged in many other great industries, and that in the matter of regularity of employment, he is very advantageously situated as compared with all other manual workers.

Mr. F. H. Rose, M.P., for Aberdeen, has stated that the membership of the Amalgamated Engineering Union in 1919 was 450,000; last month it fell to 321,000. Figures concerning other skilled unions also showed that a full 30 per cent. represented the average decline in membership. In this connection, it should be remembered that the unemployed workman cannot be excluded; it was only the employed member who was falling out. The case was very much worse with the unskilled unions; as far as he could gather, the fall in membership averaged fully 45 per cent.

The Industrial Court issued on Saturday an award relating to standard rates of wages for the electricity supply industry in Yorkshire, North Lincolnshire, North Nottinghamshire and North Derbyshire. The parties to the arbitration were the employers and trade unions of the District Council for No. 2 area, covering municipal and company-owned undertakings in the counties and sections of counties above named. The employers proposed rates ranging from 1*s.* 5½*d.* per hour for fitter drivers to 1*s.* 2½*d.* for labourers in "A" undertakings, with ¾*d.* per hour less in "B" and 1¾*d.* less in "C" undertakings, while the men suggested a rate of 1*s.* 7*d.* for the following grades: Electrical fitter, electrician or electrical wireman, mechanical fitter, armature winder, and telephone electrician or linesman. The award is that from the beginning of the first full pay week this month the rate for the grades just mentioned shall be 1*s.* 6*d.* per hour in "A" undertakings, with ¾*d.* less in "B" and 1¾*d.* less in "C" undertakings.

It will be remembered that the question in dispute recently regarding the book-binding trade was referred to arbitration. Proceedings under this reference took place at the Ministry of Labour on Tuesday, under the presidency of Sir David Harrel. The question for the court to decide was whether the Master Printers' Association of the London Chamber of Commerce, being affiliated to the London Master Printers' Association, were parties to an agreement made in December between the latter body and the Central Branch of the National Union of Paper Workers. The proceedings were private.

It is announced that under the Empire Settlement Act the total number of assisted passages so far approved to Australia, New Zealand and Canada (Ontario) has amounted to 11,338, of which 9,662 were to Australia.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The revival in the local steel and engineering trades is gradually spreading. Current indications, though slight, are encouraging. The placing of two or three fairly substantial contracts has assisted towards the general improvement. At the Renishaw iron works a new blast furnace is to be erected capable of the production of 1,000 tons per week. The equipment is to include four Cowper stoves and an air compressor. Messrs. Moorwoods, Limited, of Sheffield, have also booked a valuable order for the supply of galley ranges and equipment for oil-fired ships. The big engineering firms in the east-end of Sheffield who have been badly hit in the recent depression, are showing encouraging signs of revival. The progress of work on armament orders for the new battle cruisers, coupled with the receipt of a fair margin of new business, has put a better aspect on the outlook. A rather more robust optimism is beginning to mark the speeches of leading manufacturers. The Master Cutler (Mr. R. W. Matthews) stated recently that every day brought increasing evidence of trade improvement locally. He emphasised the possibilities of the South American market and of trade development within the Empire. Makers of mild steel are experiencing great difficulty in meeting the current demand. Furnaces which have stood idle for years are being put into commission. The unsettled position on the Continent is responsible for a big influx of orders locally for common steels. Consumers in South Wales and the Midlands are buying freely in the South Yorkshire market. All classes of basic and semi-finished materials show an upward trend in price. Acid steel billets have advanced by 1*l.* to 12*l.* per ton delivered; basic billets have put on 5*s.* to 10*s.*, making the current quotation for hard basic about 9*l.* 10*s.*, and for soft basic 9*l.* 5*s.* delivered. Steelmakers have great difficulty in obtaining adequate supplies of scrap. Quotations show an almost daily rise. There is an immediate market for guaranteed qualities. Local collieries have placed substantial orders for new wagons. Makers of axles and tyres are getting busy, though in the coil spring section Birmingham competition is severely felt.

South Yorkshire Coal Trade.—Heavy tonnages of best steams are still going away to Germany and other European countries. Collieries are well booked ahead. Prices generally are firmly maintained. An increased tonnage is going inland for home industrial consumption. Cobbles and nuts are an improving market. The supply of furnace and foundry coke is inadequate to meet a growing demand, especially with export buyers so insistent. House coal is still unsatisfactory, but an active business is passing in gas coke. Quotations: Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 21*s.* to 22*s.*; Derbyshire hards, 20*s.* to 21*s.*; rough slacks, 10*s.* to 12*s.*; nutty slacks, 8*s.* to 10*s.*; smalls, 3*s.* to 7*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Scarcity of Cleveland pig-iron is as pronounced as ever. Most makers have sold as extensively as they care to commit themselves, having disposed of their output for two months ahead, and second hands are not in a position to offer much iron for early delivery. Under such circumstances business is confined to small odd parcels, and whenever such become available they are promptly purchased at high figures. No. 1 is 130*s.*; No. 3, 125*s.*; No. 4 foundry, 122*s.* 6*d.*; and No. 4 forge, 117*s.* 6*d.*

Hematite.—East Coast hematite is almost as difficult to buy as is Cleveland pig-iron. Producers in this branch also have practically withdrawn from the market after having booked heavily for March-April deliveries. Values are steadily advancing, but are still low in comparison with rates ruling for Cleveland iron. Nos. 1, 2 and 3 are readily realising 120*s.*, both for home purposes and for shipment abroad. No. 1 hematite is a shilling above mixed Nos.

Foreign Ore.—With consumers carrying considerable stocks, and having good contracts made, there is very little doing in foreign ore, but sellers take a hopeful view of the future. Best rubio is put at 25*s.* 6*d.* c.i.f. Tees.

Coke.—Notwithstanding the high figures obtainable for export, makers of Durham blast-furnace coke, in their desire to meet essential needs of local regular consumers, are prepared to renew contracts, as far as possible, on the basis of 37*s.* 6*d.* for average qualities delivered.

Manufactured Iron and Steel.—Inquiries for finished iron and steel are numerous and heavy both for home use and for export, and are much more than manufacturers can cope with. All quotations show further upward tendency. Common iron bars are 12*l.*; steel packing, 8*l.* 10*s.*; steel billets (soft), 9*l.* 10*s.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 14*l.*; steel ship, bridge and tank plates, 10*l.*; steel angles, joists, and heavy rails, 9*l.* 10*s.*; and galvanised corrugated sheets, 19*l.* 5*s.*

Shipments of Iron and Steel.—Including 5,664 tons of pig-iron loaded at Skinningrove, 66,242 tons of iron and steel were shipped from the Tees last month. Of the 60,578 tons sent from Middlesbrough, 33,742 tons were pig-iron, 3,072 tons manufactured iron, and 23,764 tons steel, 27,476 tons of pig-iron going abroad, and 6,266 tons coastwise; 1,941 tons of the manufactured iron going abroad and 1,131 tons coastwise; and 16,875 tons of the steel going abroad and 6,889 tons coastwise. The principal importers of pig-iron were: Germany, 8,019 tons; the United States, 6,258 tons; Wales, 3,880 tons; Belgium, 3,025 tons; Italy, 2,820 tons; France, 2,265 tons; Scotland, 1,830 tons; Denmark, 1,818 tons; and Sweden, 1,351 tons. Once more India was by far the largest purchaser of both manufactured iron and steel, taking 1,220 tons of the former and 8,883 tons of the latter. Victoria received 2,632 tons of steel.

Imports of Iron and Steel.—Interesting returns are this week issued by the Tees Conservancy Commission showing the imports of iron and steel to the port of Middlesbrough from Holland, Belgium, France, Norway Sweden, Germany and coastwise, for the four months ending February 28 last, as compared with the same time a year ago, and the corresponding pre-war period of 1913–14. Unloadings of pig-iron in the past four months amounted to 2,436 tons, as against 25,045 tons twelve months ago, and 54 tons in 1913–14. Plates, bars, angles, rails, sheets and joists discharged during the period ending February last totalled 4,210 tons, as against 2,340 tons last year, and 7,906 tons for 1913–14 period. Crude sheet bars, billets, blooms and slabs imported in the past four months reached 21,720 tons as against 17,948 tons a year ago, and 14,309 tons for the corresponding part of 1913–14.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Another unsuccessful attempt was made to-day to settle the question of extending the working time of the coal trimmers and tippers employed at the South Wales ports. Representatives of the interests concerned met at Cardiff, under the presidency of Sir David Shackleton, of the Ministry of Labour, with the object of trying to arrange a settlement without referring the matter to a Court of Inquiry. The shipowners at the outset intimated that they had decided that the question should go to a Court of Inquiry at once, expressly on the point as to whether a third shift was justified or not without any mention of extra compensation to the workmen. The men's representatives contended that the question of compensation was inseparable from the general issue of the working of a third shift and could not agree to the shipowners' proposal. Sir David, in view of the sharp difference of opinion intimated that the matter would have to be further considered by the Ministry of Labour, and that in all probability the attendance of representatives of both sides would be required in London shortly. Meanwhile the acute congestion of shipping continues, and the daily list of steamers waiting for tips at which to load remains abnormally high. To-day, for instance, there were no less than 57 steamers waiting to go under the tips. At the same time the colliery proprietors are exceptionally well placed as regards orders, and in many cases firms have already sold the whole of their output over the next couple of months. In fact, a number of concerns are entirely out of the market, while those with supplies for disposal have only comparatively small quantities for which up to 35*s.* is commanded for best Admiralty large, 33*s.* for seconds, 32*s.* 6*d.* for Monmouthshires and 29*s.* to 31*s.* for drys. There is a virtual famine in the supply of smalls and buyers experience the greatest difficulty in securing even odd lots. Up to 26*s.* has been realised for best steam smalls, and 23*s.* 6*d.* for seconds, and from 19*s.* for drys. The shortage has become so pronounced that already orders, which would have been placed for Welsh coals, have gone to America. In one instance

a firm which had booked up 40,000 tons of Monmouthshires asked for the order to be increased to 100,000 tons, but this the seller was unable to do. In consequence, an order was placed for 100,000 tons of American coal. Not only are prices firm for early shipment, but a considerable business has already been transacted for delivery over the remainder of the year. The Paris, Lyons and Mediterranean Railway have placed a contract for 500,000 tons of best coal in the proportion of two-thirds large and one-third small, at 28*s.* for the large and 20*s.* for the small, while the Italian railways are also in the market for 500,000 tons over the year. Orders continue to come into the market, and notwithstanding renewed American competition in the Continental and European markets the probability is that the prices for Welsh coals will further advance. Exports of coal as cargo last week amounted to 596,100 tons, or 15,000 tons less than in the previous week. The contraction was, however, chiefly caused by inclement weather interrupting loading operations.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—The improvement in general trade which was so freely anticipated is not yet with us. Development was expected to be gradual, and there is no doubt but that business was slowly getting better until affairs on the Continent took the recent awkward turn. The action of the French in the Ruhr has caused a large shipping demand here for coal, with the inevitable result that local prices have been advanced several shillings a ton. This has had a very serious effect upon local business and has put a check on the expansion of trade so long looked forward to and so anxiously awaited. Prices of steel and iron have been advanced and buyers of all classes of material are again holding back. Much has been said about the action of the coal masters and few hold that it was a necessary step. The bald fact remains that industry will now be somewhat crippled and the recovery to something approaching normal times will be retarded. The costs in shipbuilding will be considerably increased and the placing of new tonnage will almost cease for the present.

Scottish Steel Trade.—The amount of work recently booked by the Scottish steel makers is keeping the plant in operation running steadily, but the advanced prices now required owing to the increased cost of production has put a slight check on fresh business. Last week it was decided at a meeting of the Scottish Steel Makers' Association to raise prices for steel material for the home market. The following are now the minimum selling quotations:—Boiler plates, 13*l.* per ton; ship plates ($\frac{3}{8}$ in. and up), 9*l.* 15*s.* per ton; angles (7 united inches and up), 9*l.* 5*s.* per ton; forging blooms, 10*l.* 10*s.* per ton: and stay bars, 12*l.* per ton, all delivered Glasgow stations. For export the prices of all materials are free with the exception of boiler plates, which have been fixed at 12*l.* 10*s.* per ton. These alterations in the selling prices have been responsible for a falling-off in fresh business this week, as buyers are not inclined to enter the market at the moment. Inquiries are not so plentiful, but the unsettled state of the industry on the Continent will tend to improve trade here despite the increased prices now demanded. In the black steel sheet trade a fair amount of activity is general and the work on hand will ensure steady employment for some time ahead. Not only have home buyers ordered quite a lot of material but a goodly number of export lines were fixed up lately, and inquiries now in the market, for lots for the Far East, indicate that large quantities are wanted for that quarter. The price is strong at 12*l.* per ton, delivered at Glasgow stations, for sheets $\frac{5}{16}$ in. to $\frac{1}{4}$ in.

Malleable Iron Trade.—The conditions in the malleable iron trade of the West of Scotland have varied very little over the week, but the advance in the price of fuel has had its effect on cost of production. Order books are fairly well filled at present considering the quiet times, and foreign buyers are again to the fore endeavouring to fix up some quite respectable tonnages. Prices have advanced in sympathy with raw material, and at a meeting of the Scottish malleable iron makers held in Glasgow yesterday, it was agreed that owing to the increased cost of production the basis price for "crown" bars should now be 12*l.* per ton delivered Glasgow stations.

Scottish Pig-Iron Trade.—In the pig-iron trade of Scotland the production is being rapidly taken up despite advancing prices, and makers have no difficulty in getting their output sold. For foundry iron in particular there is an ever-increasing demand, and for No. 1 quality the quotation is 6*l.* per ton, and for No. 3 it is 5*l.* 15*s.* per ton, both on trucks at makers' works. No difficulty is being experienced in obtaining these prices. Hematite iron is likewise in fairly good demand, and is strong in price this week at 6*l.* per ton, delivered at the steel works.

Shipments of Scottish Pig-Iron.—The exports of Scottish pig-iron continue on a very encouraging scale, and the amount shipped from Glasgow harbour for the week ending last Saturday, March 3, was 1,268 tons foreign and 94 tons coastwise. During the corresponding week last year the figures were 485 tons foreign and 50 tons coastwise.

CHANGES AT THE ADMIRALTY.—We learn that Rear-Admiral C. T. M. Fuller has been appointed a Lord Commissioner of the Admiralty, Third Sea Lord and Controller in succession to Rear-Admiral Sir F. L. Field, who retires. Rear-Admiral Fuller's place as Lord Commissioner of the Admiralty and Assistant Chief of the Naval Staff will be taken by Rear-Admiral A. K. Waistell.

NOTICES OF MEETINGS.

THE INSTITUTE OF COST AND WORKS ACCOUNTANTS.—Friday, March 9, in the Connaught Rooms, Great Queen-street, W.C. 2. Second Annual Costing Conference. The subject is "Standardisation in Costing."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 9, at 7 p.m., at Storey's Gate, S.W. 1. Informal Meeting. Discussion on "Aerial Ropeways." Introduced by Mr. W. A. Bowden, A.C.G.I., A.M.I.Mech.E. Friday, March 16, at 6 p.m. General Meeting. Second Report of the Steam Nozzles Research Committee.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, March 9, at 7 p.m., at the Engineers' Club, Coventry-street, W. 1. Annual Meeting. Presidential Address by Colonel Moore-Brabazon. At the conclusion of this the president will read a paper on "Aerial Photography," illustrated by lantern slides.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 9, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Ordinary Meeting. Paper on "Rolling-Mill Machinery," By Mr. R. D. C. Fell. Friday, March 16, at 7.30 p.m., "Comparative Power Costs," by Mr. C. H. Woodfield.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Friday, March 9, at 7 p.m., at the Engineers Club, Coventry-street, W. 1. Lecture, "Gas as a Fuel," by Mr. J. G. Clerk, F.C.S., M.Inst.C.E.

THE INSTITUTION OF CIVIL ENGINEERS.—YORKSHIRE ASSOCIATION.—Friday, March 9, at 7.30 p.m., in the Philosophical Hall, Leeds. Paper "Adjustment of Curves on Railroads by Hallade Process," by Mr. R. V. H. Howe, B.Sc.

THE KEIGHLEY ASSOCIATION OF ENGINEERS.—Saturday, March 10, at 6.30 p.m., in the Assembly Room, Cycling Club, Cavendish-street, Keighley. Lecture, "The Relations of Iron with Carbon, Silicon and Phosphorus," by Mr. F. C. A. Lantsberry.

THE INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday and Tuesday, March 12 and 13, at 7.30 p.m., in the Lecture Theatre, Neville Hall, Newcastle-upon-Tyne. "Vernon Harcourt Lectures," by Mr. T. R. Wilton, M.A.(Cantab.), M.Inst.C.E., on "Foundations in Dock and Harbour Works."

THE ROYAL SOCIETY OF ARTS.—Monday, March 12, at 8 p.m., at John-street, Adelphi, W.C. 2.: Cantor Lecture, "Accurate Length Measurement," by Mr. J. E. Sears, Junior, C.B.E., M.A., M.I.Mech.E. (Lecture 2). Wednesday, March 14, at 8 p.m.: Ordinary Meeting, "Industrial Arbitration," by Sir William Warrender Mackenzie, K.B.E., K.C.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, March 13, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Annual General Meeting. Presidential Address, by Professor J. S. S. Brame, F.I.C., F.C.S.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 13, at 6 p.m. Papers to be submitted for further discussion: "Some Problems Connected with the Rivers and Canals in Southern India," by Mr. Joseph Melville Lacey, M.Inst.C.E.; "An Irrigation Project of the Californias," by Mr. Sydney Lionel Rothery, Assoc.-M.Inst.C.E.; "The Influence of Silt on the Velocity of Water Flowing in Open Channels," by Mr. Arthur Burton Buckley, Junior, O.B.E., Assoc.M.Inst.C.E. Students' Meeting, Wednesday, March 14, at 6 p.m.: Paper to be read, "The Compression System of Refrigeration and Machines Operating Thereon," by Mr. F. J. Symonds, Stud.Inst.C.E. Sir Cyril R. S. Kirkpatrick, M.Inst.C.E., will take the chair.

THE INSTITUTE OF METALS: SCOTTISH LOCAL SECTION.—Tuesday, March 13, at 7.30 p.m., in the rooms of the Institution of Engineers and Shipbuilders in Scotland, 38, Elmbank-crescent, Glasgow. Annual General Meeting. Discussion on "Problems Awaiting Solution," to be opened by Professor J. H. Andrew, D.Sc.

THE INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Tuesday, March 13, at 7 p.m., in the Chamber of Commerce, New-street. Paper on "Casting Temperature Conditions and the Properties of Phosphor-Bronze," by Mr. G. L. Bailey, M.Sc.

THE INSTITUTE OF METALS: NORTH-EAST COAST LOCAL SECTION.—Tuesday, March 13, at 7.30 p.m., in the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. Paper on "The Corrosion of Metals," by W. H. Hatfield, D.Met.

THE INSTITUTE OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, March 13, at 7 p.m., at the North British Station Hotel, Edinburgh. Paper: "The Maintenance of Voltage on a Direct-Current Distribution System by Means of a Fully-Automatic Sub-station," by Mr. P. J. Robinson.

THE INSTITUTION OF STRUCTURAL ENGINEERS—LANCASHIRE AND CHESHIRE BRANCH.—Wednesday, March 14, at 7.15 p.m., at the Engineering Laboratory, Victoria University, Manchester. Further discussion on "Flexural Resistance," by Mr. A. S. Spencer, M.I.Struct.E.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, March 14, at 7.45 p.m., at the Institution of Mechanical Engineers, Storey's Gate, S.W. 1. Paper on "Multi-Wheel and Track Motor Vehicles," by Major T. G. Tulloch.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, March 14, at 7.30 p.m., at the St. Bride's Institute, Bride-lane, Fleet-street, E.C. 4. Paper on "Scientific Instruments in the Boiler House," by Mr. John B. C. Kershaw, F.I.C. Apparatus will be on view.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, March 15, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, Piccadilly, London. The Presidential Address will be delivered by Mr. R. Gilman Brown, B.A.

THE INSTITUTE OF METALS: LONDON LOCAL SECTION.—Thursday, March 15, at 8 p.m., in the Rooms of the Institute of Marine Engineers, 85 to 88, The Minories, Tower Hill, E. 1. Discussion on "The Heat Treatment of Non-Ferrous Metals," to be opened by Mr. W. B. Clarke.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, March 15, at 6 p.m. Joint Meeting with the Royal Institute of British Architects, at Savoy-place, Victoria Embankment, W.C. 2. "Co-operation between the Architect and the Electrical Engineer," by Mr. F. Hooper. F.R.I.B.A., and Mr. J. W. Beauchamp.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, March 13, at 6.30 p.m., at 85 to 88, The Minories, Tower Hill, E. 1. "The Development of the Air Pump for High Vacuum," by Mr. W. A. Dexter.

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Friday, March 16, at 7.15 p.m., at the University College, Singleton Park. Paper on "Gaseous Firing of Industrial Furnaces," by Mr. E. W. Smith, D.Sc.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 16, at 9 p.m. The Evening Discourse will be delivered by Montagu R. James, Litt.D., F.S.A., F.B.A. The subject is "The Novels and Stories of J. Sheridan Le Fanu." Afternoon Lectures, at 3 p.m.: Tuesday, March 13, Professor C. G. Seligman, M.D., F.R.S., on "Rainmakers and Divine Kings of the Nile Valley" (Lecture I). Thursday, March 15, Lieutenant-Colonel E. A. Strange, C.B.E., on "Japanese and Chinese Lacquer" (Lecture I). Saturday, March 17, Sir Ernest Rutherford, D.Sc., F.R.S., on "Atomic Projectiles and their Properties."

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, March 16, at 7.30 p.m., in the Lecture Theatre, Literary and Philosophical Society, Newcastle-upon-Tyne. "Notes on the Economical Performance of Turbine Installations in Merchant Ships," by Mr. T. S. Potts.

ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on the 5th inst., Sir James Crichton-Browne, treasurer and vice-president, in the chair. The death of Professor Röntgen was reported to the meeting, and a resolution of condolence with the family passed.

SPINNING TOPS AND GYROSCOPIC MOTION.—On Tuesday, March 6, a popular lecture dealing with gyroscopic effects and their applications to practical purposes was given by Mr. L. C. Perkin, of Leeds, to a large audience in King George's Hall of the London Central Y.M.C.A., Tottenham Court-road. The behaviour of gyroscopes under various conditions was illustrated by working models, and a discussion of the phenomena observed led up to a description to the gyroscopic control of torpedoes, the Brennan mono-rail system, the Sperry method of stabilising ships which was recently illustrated in our columns, and the gyro-compasses for navigation purposes of Sperry and Brown. The lecturer succeeded in giving a clear exposition of a somewhat difficult subject in a very interesting manner, and the Y.M.C.A., are to be commended for providing weekly lectures of this kind free to all members and at a quite nominal charge to the general public. The chair on Tuesday evening was taken by Mr. P. R. Jackson, the managing director of the Sperry Gyroscope Company, whose remarks added to the instructional value of the lecture.

THE LATE MR. J. A. D. BORNEMANN.—We regret to have to record the death, which occurred on February 23, at his residence, 8, The Avenue, Lincoln, of Mr. J. A. D. Bornemann, C.B.E., J.P., director of Messrs. Ruston and Hornsby, Limited, engineers, Lincoln, Grantham and Stockport. Mr. Bornemann was born at Amsterdam, and commenced to earn his own living as an office boy at the age of 14. For many years he studied early and late to improve his position, and at 21 he became head clerk and cashier in an important Amsterdam firm of merchants. Two years later he heard that a firm in Lincoln—owned by Mr. J. Ruston—wanted a foreign correspondent not of German nationality. Mr. Bornemann sent in his application for the post, written in four languages. The application was accepted and Mr. Bornemann acted as foreign correspondent to Mr. J. Ruston for two years and a half. In a very short time, he became the traveller for the firm, and in that capacity visited practically the whole of Europe, the North Coast of Africa, Egypt and Asia Minor. Mr. Bornemann was in Finland, when he received a message from Mr. J. Ruston asking him to return and to replace the late Mr. J. Kent, as managing director. Mr. Bornemann held the latter position for twenty-three years, until 1919. Down to the time of his death he remained a director of the firm. Whilst he acted as managing director of Ruston, Proctor and Co., and later Ruston and Hornsby, the firm carried out an exceedingly large amount of war work for the Admiralty, War Office, Ministry of Munitions, Air Board, the Departments of Mechanical Transport, Railways and Roads, Inland Waterways and Docks, &c. Mr. Bornemann was in his seventieth year. He was greatly esteemed by all in the firm of Ruston and Hornsby, and in the city.

3½-CUBIC YARD STEAM SHOVEL FOR TAKORADI HARBOUR WORKS.

CONSTRUCTED BY MESSRS. RUSTON AND HORNSBY, LIMITED, ENGINEERS, LINCOLN.

(*For Description, see Page* 300.)

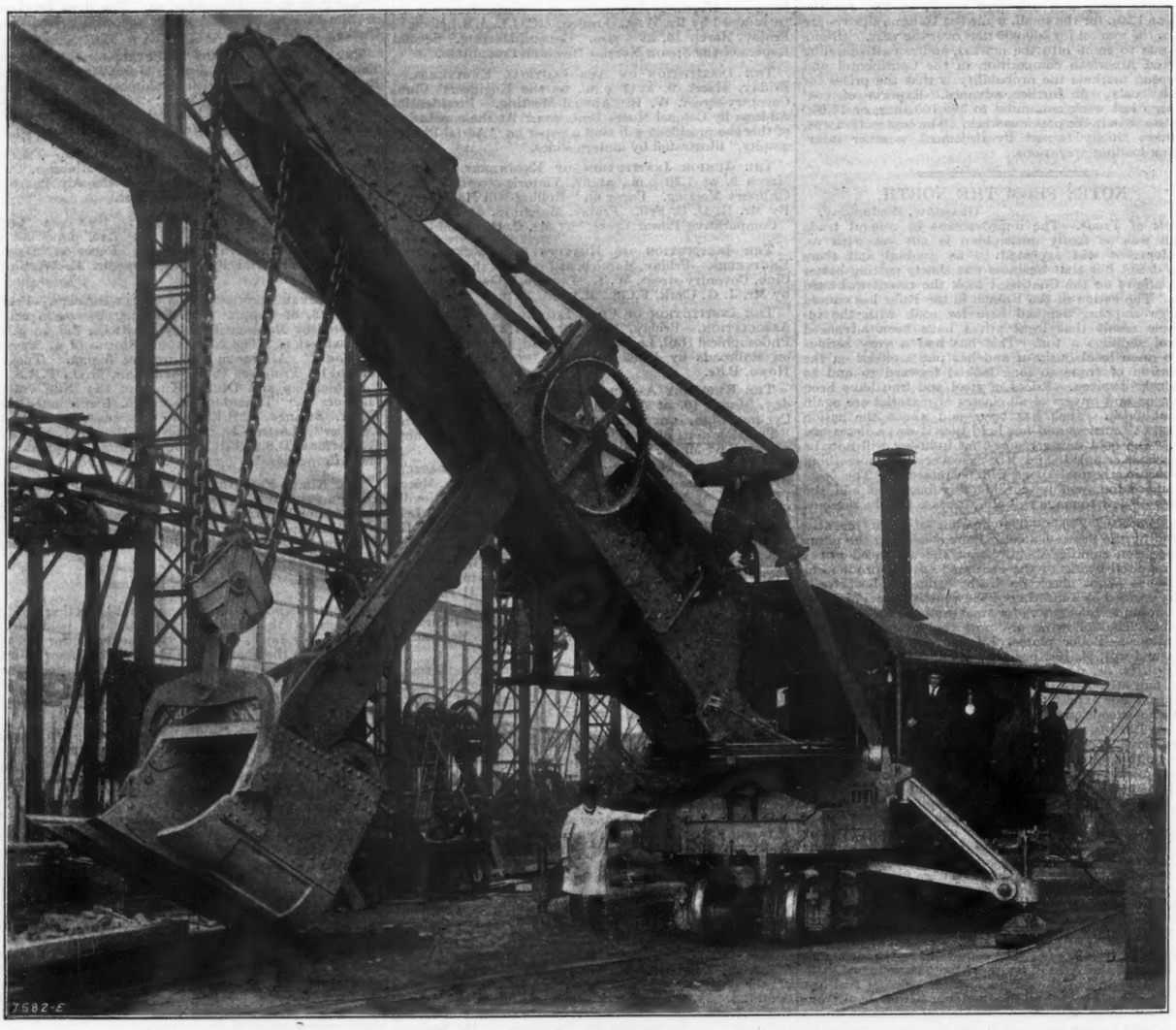


FIG. 10. GENERAL VIEW OF SHOVEL.

THE IRON AND STEEL INDUSTRY OF CZECHO-SLOVAKIA.—The British Vice-Consul at Prague, in reporting to the Department of Overseas Trade, states that the iron and steel industry in Czecho-Slovakia experienced a period of unparalleled depression during the past year. The total number of blast-furnaces in the country is 27, having a yearly capacity of 1,608,600 tons. Of these, 13 furnaces were in action in 1919, with an output of 648,000 tons; 16 in 1920, output 694,000 tons; 17 in 1921, output 543,000 tons; and 6 in 1922, output 93,000 tons.

THE DEVELOPMENT OF ARCHITECTURE.—A course of lectures is to be given at the British Museum, by the permission of the Director and Trustees, on "Recent Excavations in Mesopotamia, Egypt and the Mediterranean Countries," with a view to tracing the development of architecture from about 4,000 B.C. down to Roman and early Christian times. The lecturer will be Mr. Claire Gaudet, lecturer and examiner in art to the L.C.C., and the lectures, of which there will be twenty in the course, will be delivered on Thursday afternoons at 3.15, the first having been given on the 1st inst. The treatment will not be purely technical, but framed on archæological and historical outlines, and the opportunity will be taken to discuss the arts and crafts of the people. The course promises to be a most interesting one. Slides will be shown, and visits made to the Museum galleries. Further particulars of this series of lectures, with the charges for whole or part of the course, may be obtained from the hon. sec., "Recent Excavations," 120, Cheyne-walk, Chelsea.

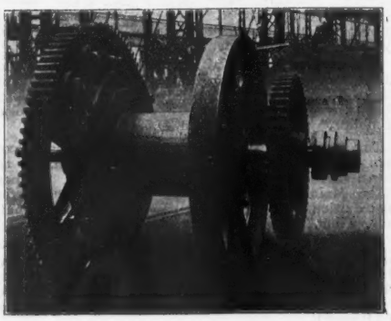


FIG. 11. HOISTING DRUM.

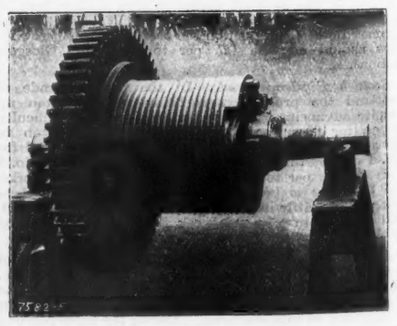


FIG. 12. SWINGING DRUM.

WASTE IN SLATE QUARRYING.—The slate industry, in important source of roofing tiles, blackboards, billiard-table tops, switchboards and other products, labours under a staggering handicap of waste, states the United States Bureau of Mines, which has completed a study of the subject. According to the mineral technologist of the bureau, in most slate-producing districts the waste averages 70 per cent. to 90 per cent. of gross production. In one quarry in Vermont an average of 16 tons of rock is removed for each ton of good slate. After a careful study of the waste problem from all angles the conclusion has been reached by the Bureau of Mines that the efforts of the quarryman should be devoted to waste elimination rather than to waste utilisation problems.

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(*For Description, see Page* 300.)

FIG. 1.

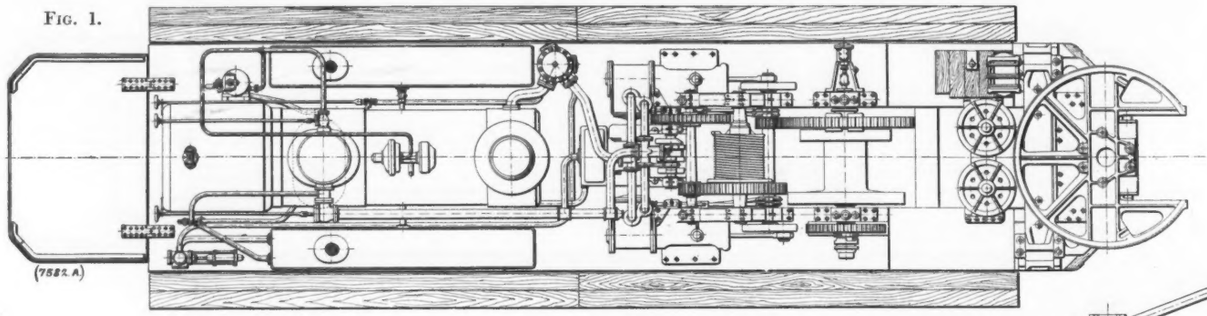
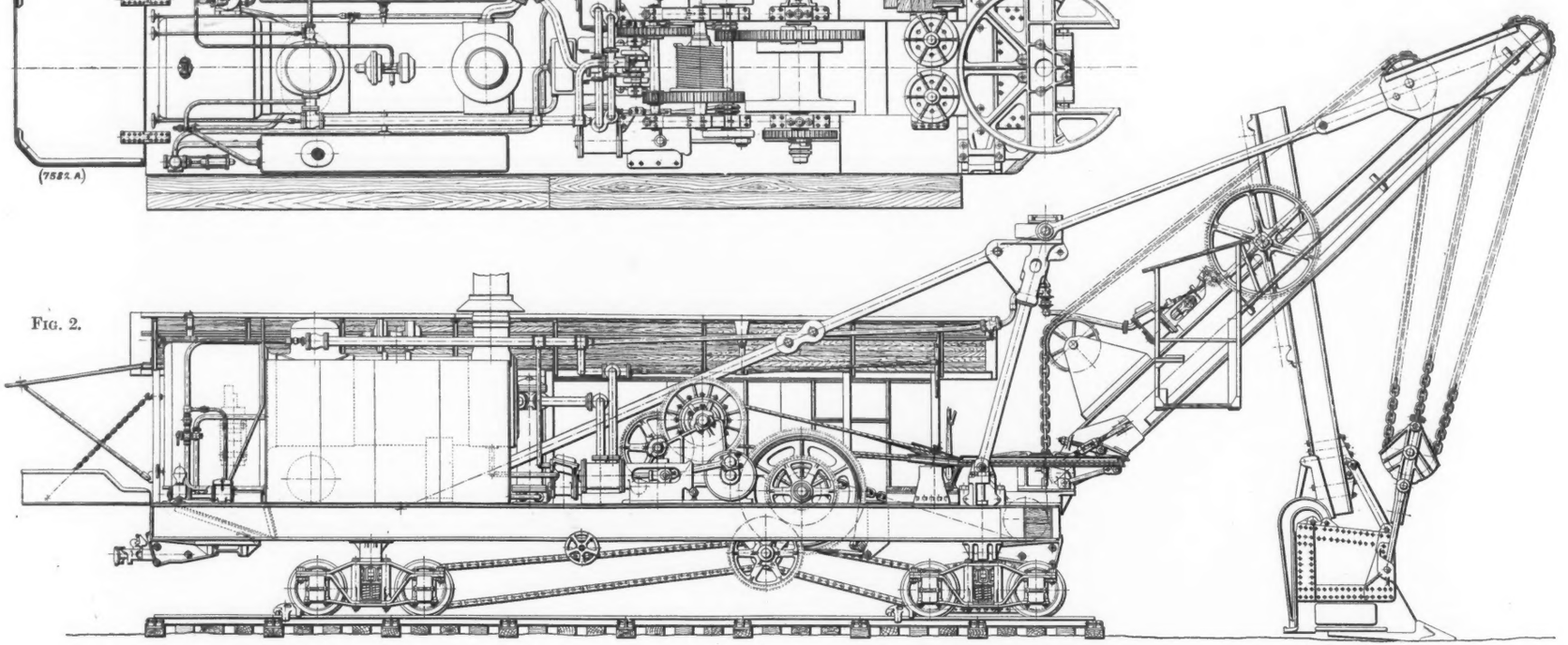


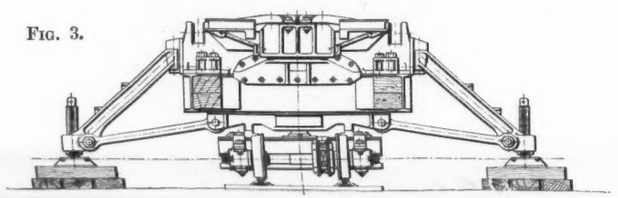
FIG. 2.



Scales for Figs. 1, 2, and 3.

Inches 12 0 1 2 3 4 5 10 15 Feet.

FIG. 3.



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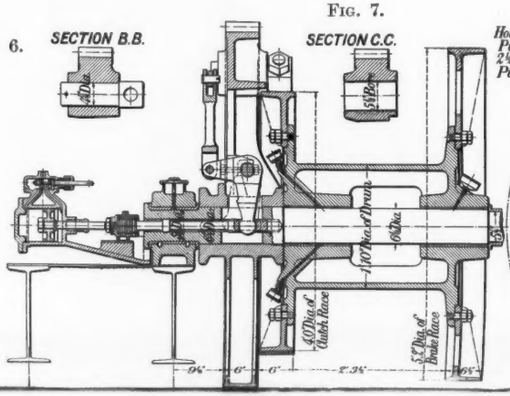


FIG. 4.

FIG. 7.

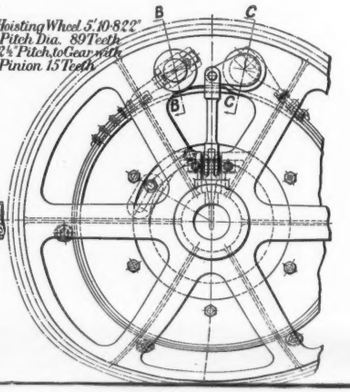


FIG. 5.

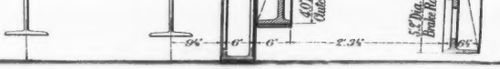


Fig. 4.

Fig. 5.

Fig. 8.

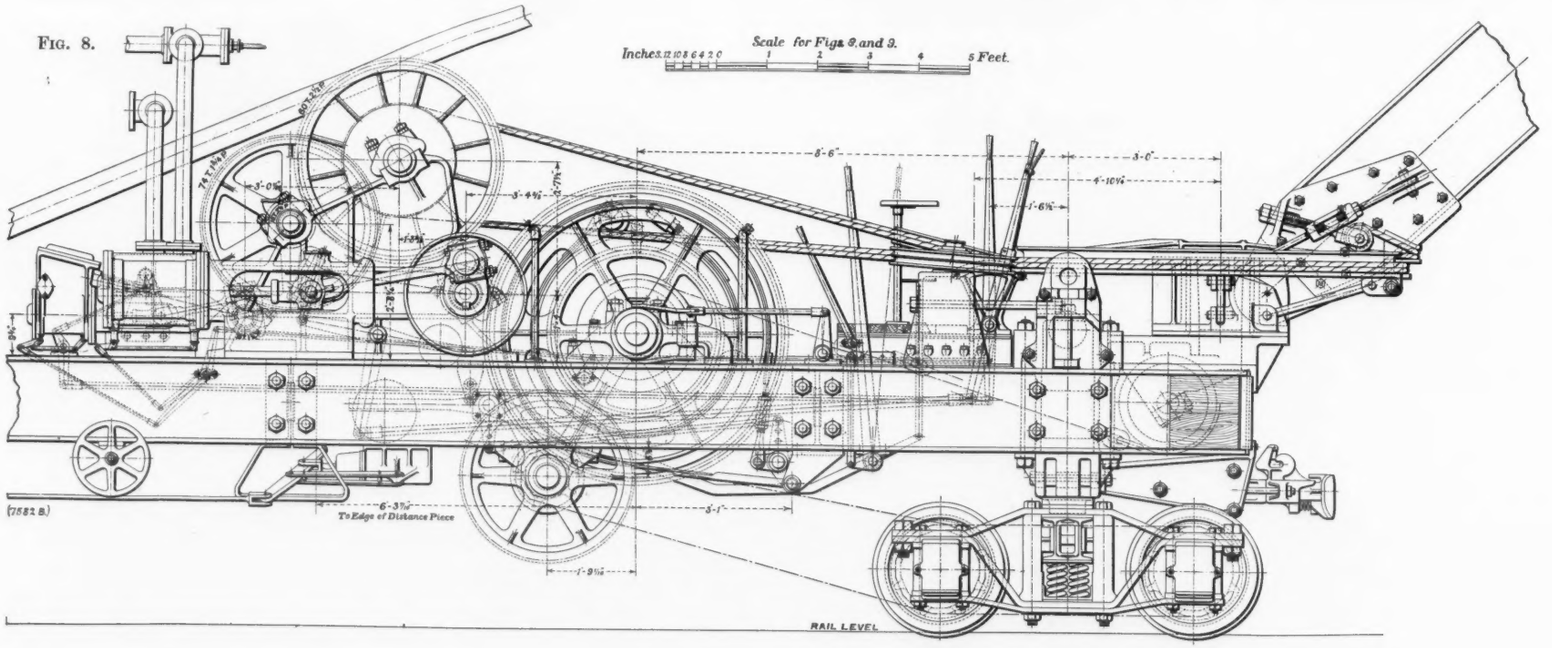
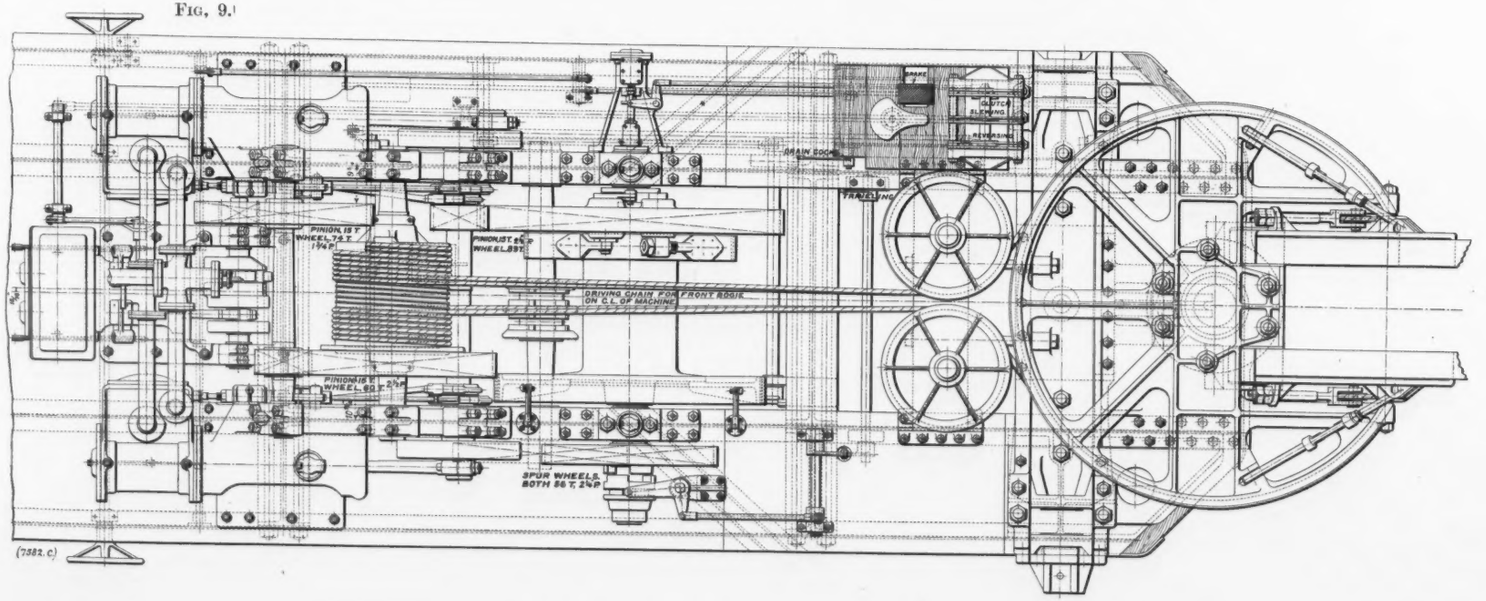


Fig. 9.



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Two-Page Plate. — 3½-*CUBIC YARD STEAM SHOVEL FOR TAKORADI HARBOUR WORKS.*

ENGINEERING.

FRIDAY, MARCH 9, 1923.

TURBINE TROUBLES.

IT was Mr. Dooley who pointed out to the long-suffering "Henessey" that there was no "*news*" in being good, and that what the public wished to hear about were the doings of our social failures. A somewhat similar rule holds in matters mechanical. There may not be more joy over one turbine mishap than in the steady performance of their assigned task by 99 "just" turbines, but the occasional failure certainly excites a much keener interest. This is not to be attributed (save perhaps in the case of trade rivals) to the certain joy, which the cynical French philosopher asserted, we all took in the minor misfortunes of our friends. As a matter of fact the "just" machine, which needs no amendment, teaches us very little, whilst much may often be learnt from a breakdown. Of course, this rule does not invariably hold, since some accidents, as for example, the Titanic disaster, originate in an exceptional series of coincidences little likely to recur again.

In general, however, a failure implies some weakness in design or material. It would be unsafe to assume that a "no trouble" machine had everywhere the same factor of safety, and it is the ordinary, not the exceptional, failure which shows us where margins have been cut too fine. From the technical standpoint much would be gained by the publication of full and complete details of machinery failures of all kinds, but this desideratum is seldom achieved save in official inquiries, which in some cases, however, are conducted by lawyers, who fail to bring out the really important points.

In general it is extremely difficult to get a plain unvarnished description of a mishap. This holds even when the trouble is of minor importance and when there is no intentional concealment. Those immediately concerned can hardly help forming some theory as to the accident and publish only such observations as are consonant with this.

American reports on steam turbine failures have commonly been much more frank and open than it is usual for them to be in this country. Possibly the stricter interpretation which is placed here on the law of libel, may be a factor in the matter. Mr. Longridge used to publish annually most instructive reports on engine failures, but there are many more engine builders than steam turbine makers, and hence the accidents on which Mr. Longridge commented could seldom be identified with any particular firm. Nevertheless, much information as to dangerous and safe types of construction has gradually become common property, and it is of interest to note, in the light of present knowledge, the excessively bad details illustrated in some of the early books on turbine construction.

It was Sir Charles Parsons who laid down the rule that if a non-lubricated surface is to move at a high speed in close contiguity to a fixed surface, one of the two must be merely a thin fin, so that if a touch occurs, wear might take place without any serious development of heat. The very serious accidents which have occurred from the bursting of turbine discs seems to indicate that turbine engineers might well take a leaf out of the book of the other great pioneer of turbine design, viz., Dr. de Laval. In general, no doubt, the designer aims at making his machinery with the same factor of safety throughout as the Deacon did in the case of the one-horse shay described by Oliver Wendell Holmes. In certain cases, however, this involves the risk that, like the shay, the machine may collapse "all at once and nothing first," an eventuality which has been very nearly realised in some of the accidents due to the burst wheels. Dr. de Laval avoided this risk by reducing the section of his wheel near the rim, thus providing a "breaking piece" which would ensure that if failure did occur the fragments would be incapable of causing a general wreck.

A paper, in which the authors had collected together much interesting information on turbine failures, was read before the North-East Coast Institution of Engineers and Shipbuilders, on February 16 last, by Professor A. T. Mellanby and Mr. W. Kerr. This was contributed by invitation with the idea of starting a general discussion on the whole subject, and in the hope that turbine builders might throw their own special experiences into the common stock. It cannot be said that this aim was altogether achieved, and no doubt trade interests must always conflict with such a counsel of perfection.

Nevertheless some highly interesting points were brought out both in the paper and in the discussion. The authors very appropriately classified breakdowns as blunders or mishaps, the former arising from a neglect of well-established principles and the latter being merely the inevitable accompaniment of the march towards higher and higher outputs, speeds and efficiencies. Steam temperatures and pressures have increased enormously of late years. At the beginning of the century the standard speed of a 3,000-kw. machine was 750 r.p.m., whilst to-day an output of 15,000 kw. has been obtained at 3,000 r.p.m. Pressures, too, have risen from less than 150 lb. per square inch at the beginning of the century to in some cases, more than double this figure, and there has been an equally drastic rise in steam temperatures. An advance of this magnitude necessarily involves the transcending of experience, with the certainty that, in the language of the insurance market, some of the risks accepted would prove losses. Failures of this kind may reflect little or no discredit on the men who are bold enough to make the adventure. Such failures often pave the way to the next advance, though they may check progress temporarily. At present turbine builders seem inclined to reduce blade speeds in view of the disasters recorded, although in large modern machines blade speeds have never yet approached the figures which Dr. de Laval showed to be practicable a quarter of a century ago. The check is probably only momentary, as not only is there a steadily increasing demand for still further reductions in the weight and cost of large units, but there is reason to believe that for high efficiencies blade speeds should either be very high or very moderate.

In this connection, Mr. Carnegie stated in the discussion that in 1913 Sir Charles Parsons built a large molecular pump for X-ray work. The discs were of saw steel, 18 in. diameter and ⅛ in. thick. They were mounted on a shaft and ran in compartments. At a speed of 5,000 r.p.m. serious disc vibration was met with, the amplitude of which was such as to bring the edges into contact with the walls of the compartments in which the discs ran. At

lower speeds, however, there was no oscillation. This observation is of much interest, since although similar phenomena have been observed with rubber discs run in air at much lower speeds, it was not clear that the effect was not in part due to the presence of this air, and it seemed conceivable that if run in vacua, the vibration observed with rubber might not occur. It seems rather surprising that the critical speed for these discs was as high as 5,000 r.p.m., as it would be natural to expect that any vibration of sufficient amplitude to lead to contact with the casing, would have a much lower periodicity, and it is further difficult to see what periodic force, could in this case be responsible. Of course, it is well known that, it has so far proved impossible, to determine with accuracy the stresses in such discs. According to Love, however, (*Enc. Brit.*, vol. ix, page 157), a complete solution has been found for the case in which in addition to the centrifugal forces the disc has a certain specified radial force applied to its rim. The practice of hammering large circular saws to produce in them a condition of initial strain may have a bearing on this question.

Mr. Carnegie further claimed that for the very high speeds now demanded the reaction turbine had certain advantages over the rival type. For security against the whirling of the shaft it is very important to reduce to a minimum both the weight imposed on it and the distance between centres of the bearings. There is thus an inducement to make turbine discs as thin and light as possible, and if such discs are run in separate compartments, as with impulse turbines, there is a liability to the setting-up of disc vibrations, which in fact are generally held to be responsible for burst wheels. When, however, such discs are embodied in a reaction turbine, they can be made to abut one on the other at their peripheries, thus rendering disc vibration impossible.

In many cases disc failures seem to have started at the balance holes, which it is usual to provide in order to ensure an equality of pressure on both sides of the disc. In their paper, Professor Mellanby and Mr. Kerr mentioned a case in which these holes were omitted, with consequent trouble at the thrust block. To-day thrust block troubles ought not to exist, since provided the lubrication is sufficiently ample the Michell block seems capable of carrying almost any loads. The lubrication must, however, be adequate and in some cases, engineers may have to revise their ideas as what constitutes an ample supply of oil.

A curious failure occurred not long since to a marine turbine of Continental design. Some original ideas in the way of lubricating one of the turbine bearings were adopted, with the result that the brass wore away to such an extent as to transfer its load to an adjacent shaft bearing. The effective length of the turbine shaft between bearings was thus nearly doubled, with the result that whirling occurred and the blading was wrecked.

In the course of the discussion Dr. Hatfield expressed some doubt as to the growth of cast-iron at moderate temperatures, but the evidence in favour of this phenomenon seems too strong to be easily upset. No doubt cast-irons vary much in this regard, and some turbine makers claim to have discovered mixtures free from the fault.

Blading troubles have been not uncommon with some types of turbine, and much interest attaches accordingly to Mr. Walker's statement that on recently overhauling the turbines of the King Edward, constructed twenty-one years ago, the blading was found to be in perfect condition. This observation seems to point to lime and not water as the active agent in eroding reaction blading. Mr. Walker's observation indeed is in full accord with what Admiral Oram stated at a meeting of the Institute of Metals in 1916. In land station practice lime is often found deposited as a slightly adherent film on the blades, the entrance edges of which feel roughened to the touch. Mr. Carnegie suggested that stainless iron which could be used in the fully annealed condition seemed a promising material for blades.

Mr. Walker seemed inclined to attribute certain gear teeth failures to internal strains produced by heat treatment, pointing out that the nominal factor of safety against bending stresses was as much as 100 to 1 in the case of some single-reduction pinions which had failed. This view was not accepted by Dr. Hatfield, who described some curious experiments on notched bars, which were submitted to blows, at the rate of 90 per minute, of a hammer weighing 4·7 lb. and falling through a height of 2 in. The piece was rotated through 180 deg. between successive blows, and failure occurred after 1,700 blows. On reducing the fall to $\frac{1}{4}$ in. fracture was produced after about 1,000,000 or 2,000,000 blows, and he suggested as one deduction from these experiments that if gear teeth suffered from even the slightest hammering failure might be anticipated.

THE HELICOPTER AND ITS USES.

IT is rather remarkable that, after several centuries of fruitless effort and after mechanical flight has been successfully achieved by other means, the helicopter should continue to fascinate the inventor. We can only imagine that the problems involved are so numerous and difficult that to many men the attraction really lies in the possibility of surmounting them. Of the many difficulties, the least is that of obtaining the necessary vertical lifting force, and several machines capable of lifting themselves off the ground have, in fact, already been produced. Even this particular problem cannot, however, be regarded as solved, since the necessary lift has only been obtained by the consumption of an inordinate amount of fuel. The remaining difficulties of providing for horizontal motion, of ensuring stability and control in flight, and of securing a safe landing in the event of engine failure, are much farther from solution.

While it cannot be denied that the ability of the helicopter to rise from, and alight in, a confined space would be a valuable feature in connection with aerial transport, since it would enable air routes to commence and terminate in the hearts of large cities and would also lessen the danger of landing in fogs, it must be remembered that when landing in a high wind, the direct-lift machine would be at a disadvantage in comparison with the aeroplane. The only other special characteristic of the helicopter, viz., that it can, or should be able to, hover over any particular spot, has no particular interest from the point of view of air transport, the object of which is to convey passengers or goods through the air from one place to another as rapidly as possible, and not to remain stationary. The possibility of the ideal helicopter being able to hover has a somewhat greater attraction from the military standpoint, and it is presumably for this reason that the Governments of several countries, including our own, have been endeavouring for some time to produce a machine of this type. At last year's Air Conference it was announced by the Director of Research that public funds were being expended upon the development of a helicopter and that an encouraging preliminary flight had been made. What progress, if any, has been made since then we are unable to say, but we are inclined to think, as the prospects of success are by no means bright, the expenditure might well have been allocated to matters of more immediate utility.

The reasons upon which this view is based were given in our issue of November 26, 1920, on page 710, when discussing a paper read before the Royal Aeronautical Society, by M. Louis Damblanc, who was engaged in investigating the subject of the helicopter on behalf of the French Government. Briefly, both an aeroplane and a helicopter derive their lift from the reaction resulting from the downward motion of a mass of air, but the aeroplane must be the more efficient of the two since it operates by driving a large mass of air downwards at a low velocity by means of its wings, while the helicopter drives a smaller mass of air downwards at a higher velocity by means of its lifting screws. The higher efficiency of the former follows from the fact that, for a given mass of air, the reaction is proportional to the velocity imparted to the air, while the work which must be done to set the air in motion is proportional to the square of the added velocity; the work necessary to obtain a given lift is therefore directly proportional to the downward velocity imparted to the air. Theoretically it should be possible for the helicopter to equal or exceed the efficiency of the aeroplane, if the lifting screws of the former were made large enough, but the weight of such screws and the difficulties of constructing and driving them seem to present insuperable obstacles to the practical realisation of an efficient helicopter.

With these and other similar arguments, Major F. M. Green showed, in a paper read before the Royal Aeronautical Society on the 1st inst., that the case for the helicopter in connection with aerial transport was a rather hopeless one. He was, as events proved, preaching only to the converted, since none of the speakers in the discussion on the paper had anything to say in favour of this application of the helicopter or even of its use for military purposes; balloons or airships, the author suggested, offered a more promising method of meeting the particular class of military requirements for which the use of the helicopter was conceivable. In conclusion, Major Green agreed that those directing the official policy of the country in aeronautical matters should not necessarily be influenced by the same considerations as would prevent a private constructor from attempting to produce a direct-lift machine, but he indicated a desire to know the precise arguments which had led the Air Ministry to undertake experimental work on this type of aircraft and what results had been obtained. This information would certainly be extremely interesting to all concerned with aeronautics from the scientific, service and commercial standpoints, and we trust that the authorities will see fit to make some detailed information on the matter available at no distant date.

ATOMIC PROJECTILES AND THEIR PROPERTIES.

AT the Royal Institution on Saturday afternoon last Sir Ernest Rutherford, F.R.S., delivered the third lecture of his course on the above subject.

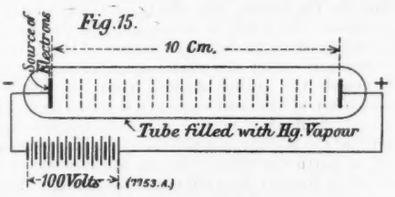
Professor Rutherford said that on the last occasion he had described the effects produced by relatively slow electrons impacting on atoms of matter. These electrons had a speed of about 3,000 km. per second, which was that due to a fall through about 25 volts. The first obvious effect was the removal of one of the atom's outer electrons by the impinging electron, thus leaving the atom ionised. Following out the consequences of this production of ions by collisions he had drawn attention to certain remarkable and unexpected results, observed when atoms were bombarded by a very great number of electrons. If the electron that impinged on another in an atom had not enough energy to remove this entirely from the atom it might nevertheless have sufficient to jump up the electron struck, into a position further away from the nucleus, in which position this displaced electron would be temporarily stable. The atom thus acted on was in what Professor Bohr had called a stationary state. The electron displaced, as described, might remain in its new orbit for some time, possibly for 1/1,000th of a second, or for 1/10,000th of a second, or even less. When it fell back into its original orbit it emitted a definite unit of radiation, the wave-length of which was defined by quantum relationships. The radiation produced thus in any one falling in of an individual electron, gave one single line in the spectrum.

If a gas were subjected to an intense bombardment by electrons, as could be provided for by means of the electrons emitted from a hot filament, we could arrange matters so that a large number of the atoms were in this transition state, giving out this special type of radiation. When a unit of this radiation met a normal atom, its energy was completely absorbed by this atom, one of whose electrons was jumped up in its turn to the transition position, and in falling in again a little later on, generated anew a fresh pulse of radiation.

If, then, we had a very considerable number of atoms in these various stages, it was quite possible to remove completely some of their electrons by bombarding these already excited atoms, with electrons having an energy less than the normal ionisation value. This phenomenon, observed when the bombarding electrons were exceedingly numerous, was known as cumulative ionisation. It was thus possible to form an arc in a gas with less than the true ionisation potential. In the case of mercury the true ionisation potential was about 10 volts,

yet once a discharge was established through mercury vapour, the arc could be maintained with electrons having an energy due to a fall through only 5 volts. The case of helium was still more remarkable. The normal ionisation potential was 24 volts, but once formed, the arc could be maintained with electrons having the energy due to a fall through 4 volts. The normal ionisation potential varied from atom to atom, the extreme range of values being in the ratio of about 5 to 1.

The excitation potential was, Sir Ernest said, governed by the electron bombardment. To illustrate this he took the case represented diagrammatically in Fig. 15. In this was shown a vacuum tube with its electrodes 10 cm. apart, and with 100 volts difference of potential. At the negative electrode a supply of electrons was produced by, say, a hot filament (not shown), and the tube was filled with the vapour of Hg at a pressure corresponding to the room temperature. The electrons accelerated by the field moved from left to right. In the conditions stated, they had a very short free path making, in fact, many thousand collisions



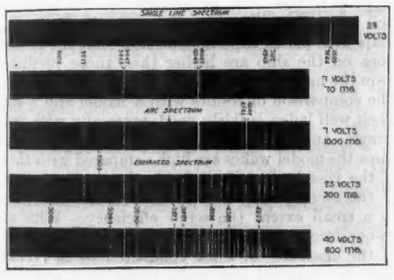
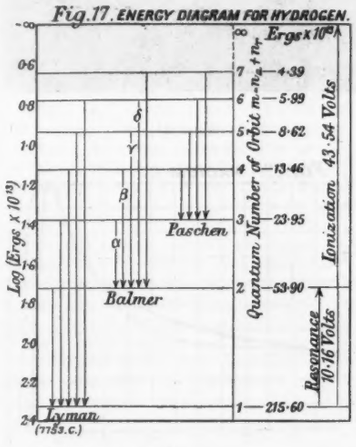


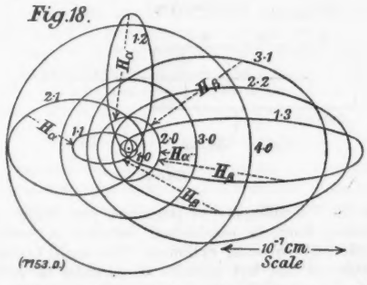
FIG. 16.

per centimetre of their course. These collisions, however, were all of the elastic type, so that after a traverse of 5 mm. the energy acquired by the electron was very nearly the same as if no collisions had occurred. In this distance of 5 mm. the electron would, in the conditions represented in the diagram, have fallen through 5 volts, and at this point it was found that a green phosphorescence appeared in the tube, and there was another glow 5 mm. further on, these diffuse bands of faint fluorescence being repeated at the same interval all along the tube. The electron on starting from the negative electrode made at first only elastic collisions, so that after traversing 5 mm. it had acquired the energy due to a fall through 5 volts. It was then able in its next collision with a mercury atom to move an electron to the first exciting position, losing in this collision the whole of its own energy. The electron struck and displaced soon fell back to its normal position in the mercury atom, and we got in consequence the green phosphorescence found. The colliding electron got up speed again during the next 5 mm. traversed, and the process already described was repeated at these intervals all along the tube. These results were obtained, it would be seen, with voltages far below the normal ionisation potential by having a sufficiently dense gas in the tube.

The next point that arose was the bearing of these results on the genesis of the spectra of gases. Some observations by Foote and Mohler are represented in Fig. 16. They fired electrons into potassium vapour and examined the nature of the light emitted. When the exciting electron fell through 3·5 volts they obtained the single-line spectrum shown at the top, which lay in the ultra-red. Actually the line shown was a doublet exactly analogous to the D lines of sodium. Potassium had an ionisation potential of only about 4 volts, hence with a fall through 7 volts these observers obtained the arc spectra shown. With this voltage the impinging electron removed an electron right out of the potassium atom and at a later stage more than one electron was removed, leaving the atom with a surplus of two positive charges. In such conditions with a 25-volt fall the enhanced spectrum was obtained. Proceeding along this line we had been able to follow out very clearly the conditions in which various series types of spectral lines were generated, and had in fact a very good general idea of the process.

Consider the simplest case, that of the hydrogen atom. This had a single electron, and the different levels at which this electron might be temporarily stable are indicated in Fig. 17. In its innermost and permanent position the electron revolved in a circle, the level corresponding to which is represented by the lowest line marked Lyman in Fig. 17. When the hydrogen atom was ionised the electron was entirely removed, but if the excitation were less strong it might merely be jumped up to one or other of Bohr's stationary states, which were defined





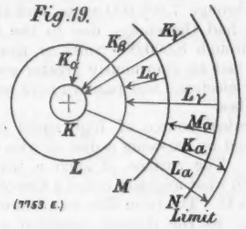
A few of the inner orbits which may be occupied by the electron of the hydrogen atom. Actually these orbits are perturbed so that they are not exactly closed or cyclic. There is present a *slow* progressive motion of perihelion. The illustration represents very closely an "instantaneous photograph" of the possible states, while a "time exposure" would give a solid field of ink on account of the progressive motion.

by the quantum relations and are represented by the different levels or orbits shown in Fig. 17. The energy required to shift an electron from the innermost orbit to infinity was $215{\cdot}60 \times 10^{-13}$ ergs.

Suppose an electron had been moved to one of the "temporary" levels, then the ordinary spectrum of hydrogen was produced by the return of this electron, not to its innermost or normal position, but to the level corresponding to 2 quanta and marked Balmer in the figure. The α, β, γ and δ lines of the ordinary hydrogen spectrum were in fact produced by the falling in of an electron to this position from the different levels shown. These lines were in the Balmer series. If the electron fell into the lowest or normal position we got the Lyman series of lines. Why it was possible for an electron to remain temporarily in a "stationary" position was unknown, but the corresponding levels were accurately defined by the quantum relationship, the difference of the energy corresponding to different stationary states being always an integral multiple of the quantum.

The same type of explanation of spectra held for all atoms. No one atom at any one moment gave all the lines of its spectrum, but when a great number of atoms were radiating we got the complete spectrum as the sum of individual contributions. To illustrate the complexity of the phenomena, Professor Rutherford showed Fig. 18, in which Foote and Mohler had plotted a number of the inner orbits, which might be occupied by the single electron of the hydrogen atom. Some atoms had over 90 electrons and with these matters were accordingly very much more complex.

So far, the speaker proceeded, he had dealt with the effects of slow electrons, and it was of interest to follow out the results of increasing the speed from that due to a fall through say, 30 volts up to falls through 100,000 volts or 200,000 volts, and to see if we got the same kind of optical effects. With such speeds we could map out the energy levels right into the centre of the atom. These for a heavy atom are represented (not to scale) in Fig. 19.



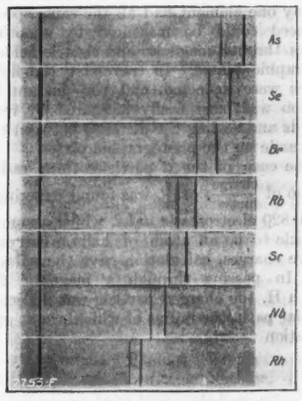


FIG. 20.

The levels shown are connected with radiation of the X-ray type, those corresponding to the visible part of the spectrum being much further out. The electrons most difficult to remove were those occupying the K orbit, which was believed to be circular. The next was known as the L orbit, after Barkla, and the others by preceding letters of the alphabet.

X-rays could be excited by electrons in exactly the same way as the lines of the ordinary visible spectrum. If a very swift electron having an energy corresponding, say, to a fall through 90,000 volts, impinged on an atom it might by good fortune collide with and knock an electron out of the K orbit. The whole atom was disturbed by the loss of one of its two K electrons. Nature abhorred a vacuum, and the gap was almost instantly filled. This might be accomplished by the falling in of an electron belonging to the L orbit, or from any one of the other orbits, or finally from right outside the atom. Such electrons as fell in from the L, M, or other orbits would have course to be replaced in their turn. From what had been said before we might anticipate that in this way we might get X-rays, corresponding to a fall from L to K, from M to K, and so on, and this was precisely what was found. As determined by Siegbahn (see Fig. 20) the K radiation from different metals consisted of two strong lines, and a third faint one, which were known

respectively as the Kα, the Kβ and the Kγ rays. In the photograph the γ line could be distinguished to the left of, and close to, the β line. In the case of lead it required a fall through 86,400 volts for an electron to acquire sufficient energy to give the shortest K radiation. Much less energy was required to excite the L radiations. For lead the values were 13,000 volts for the L radiation, 15,200 volts for the L_2 and 15,800 volts for the L_3 line. To obtain the M lines about 2,500 volts sufficed. Thus in a general way it would be seen that the excitation of the X-ray spectrum was very similar to that of the visible spectrum, but the colliding electron required much greater energy.

The most energetic projectiles were provided by radioactive bodies. The electrons constituting the β rays had energies corresponding to falls through, in some cases, as much as 3,000,000 volts, whilst the highest voltages now used in laboratories were generally about 100,000 volts, and but rarely 200,000 volts or 300,000 volts.

The α particles had, moreover, a higher energy than the β rays. Those emitted by radium C had as much energy as an electron would acquire by a fall through 7,600,000 volts, and those from thorium C had the energy due to the fall of an electron through 8,500,000 volts or more. Such projectiles had an enormously greater energy than that of the electrons and positive rays produced in vacuum tubes.

A convenient source of high speed α particles was obtained by exposing a disc or wire to radium emanation. The surface of such a wire became covered with what might be called a film of radium B and radium C. The term film was, however, really a misnomer as the deposit consisted of isolated specks of these bodies. The α particles liberated from any one element had all the same speed, and this speed could be measured by shooting the particles through magnetic and electric fields on to photographic plates. In traversing the fields the particles were deflected, and the amount of the deflection was most easily measured by reversing the fields and scaling the distance between the two traces made on the photographic plates.

In the case of the α particles from radium C, the ratio of $\frac{\text{charge}}{\text{mass}}$, or $\frac{e}{m}$, was found experimentally to be 4·820 electrostatic units, whilst assuming the α particle to be an atom of helium carrying two negative charges, calculation gave the value 4·826 units. In passing through a magnetic field of strength H, the charged particle was deflected into a circular path, the radius of which ρ, was given by the relation

$$H\rho = \frac{m\,u}{e}$$

where u denoted the speed of the particle. In the case of the α particles from radium C this velocity was found to be $19{\cdot}22 \times 10^9$ cm. per second.

The α-rays were very "stiff" as compared with the cathode rays. With a magnetic field of 10,000 the radius of curvature of the α-rays was about 40 cm., whilst an electron moving with the speed due to a fall through 400 volts would, in such a field, have its path bent into a circle of but $\frac{1}{5}$ mm. radius.

Having obtained in the way described the speed of the α particles from radium C, those of all other α particles could be determined by observing their "range" in air, since Geiger had shown that this range and the speed were connected by the equation

$$v^3 = k \times \text{range in cm.}$$

It was Bragg who first observed that α particles had definite ranges, and the whole effects produced by them, whether phosphorescent, photographic, or ionising, vanished if this range were exceeded.

By passing such rays through supersaturated air Wilson had succeeded in photographing their tracks, owing to the fact that moisture condensed round the atoms ionised by collisions with the particle. A typical photograph is reproduced in Fig. 21, where the upper track is due to an α particle and the lower to a β-ray. The ionisation produced by the former is so intense that the water droplets ran together, giving a solid line, whilst in the case of the β track, the separate ions can be seen. The α-ray was in short a very efficient ioniser, whilst high-speed β-rays were not.

Professor Henderson had recently made accurate determinations of the rate at which ionisation varied with the range. Some of his results are shown in Fig. 22, where the ordinates represent the intensity of the ionisation plotted against the range. It will be seen that at short ranges, at which the speed of the particle is high, the ionisation is relatively low, but it steadily increases to a certain maximum and then falls very suddenly to zero.

The effects of single α particles can be readily demonstrated by using the Geiger counter shown in

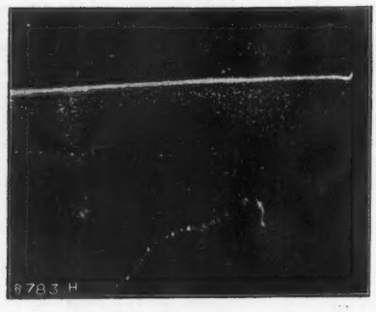


FIG. 21.

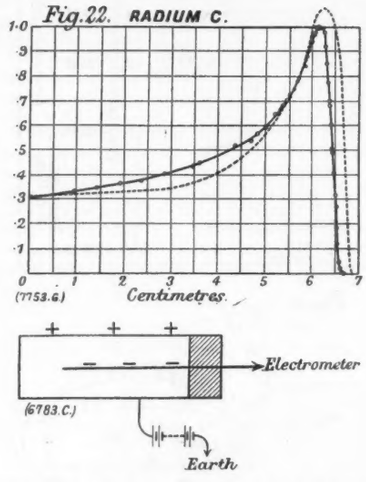


Fig. 23. A difference of potential, just below the sparking limit, is established between a central needle and an outer cylinder. The small opening visible on the left permits α particles to enter, with the result that the air inside the counter is ionised. Owing to the strong field in which these ions are liberated they acquired speeds so high that they are able to ionise other molecules with which they collide. As was explained in the previous lecture, a transitory current is thus established between the needle and the casing, and can be used to actuate a string electrometer, which gives accordingly a photographic record of the entrance of each individual α particle into the counter.

PERSONAL.—At a general meeting of the Royal Institute of British Architects on the 5th inst. Sir John James Burnet was elected by the members, and his name will be submitted to His Majesty the King as a fit recipient of the Royal Gold Medal for Architecture for the year 1923.—Sir W. G. Armstrong, Whitworth and Co.'s Hydroelectric Department has now moved from 8, Great George-street, to 51, Victoria-street, where additional accommodation has been taken adjacent to that occupied by the same firm's civil engineering department. The new telephone number is Victoria 1761, and the telegraphic address is "Ubiquity, Sowest, London."—The Consolidated Pneumatic Tool Company, Limited, of Egyptian House, 170, Piccadilly, London, W. 1, have been appointed sole selling agents for Weldrics and Weldrines patent electrodes.—Messrs. Wailes Dove Bitumastic, Limited, of Newcastle-on-Tyne, inform us that they have opened a branch office at 2, Bank-street, Sheffield, and that they are also arranging for a stock of their materials to be kept at Sheffield to facilitate prompt execution of orders in that district.

NOTES.

MEASURED MILE TRIALS AND MODEL EXPERIMENTS.

The discrepancies met with in tests with models and actual ships were discussed by Mr. G. S. Baker in a paper on "Measured Mile Trials and Other Ship Propulsion Data," which he read before the North-East Coast Institution of Engineers and Shipbuilders on Friday, March 2. Complete comparison of the results will not be possible until it becomes the practice to instal instruments to measure the thrust and torque on the shafts. The results are always liable to error. In the case of model experiments there is little data available of the skin friction of long surfaces at high speeds. The scale effect must be considered in dealing with model and full-size ship propellers. Incorrect assumptions regarding wake conditions are possible, and there is a likelihood of introducing errors in estimating from the performance of models under one set of conditions what will happen with the ship under other circumstances. In an actual ship trial errors may be introduced through the acceleration of the ship when on the course, the effects of tides, weather conditions, the depth of water and the absence of knowledge of the mechanical efficiency of the driving mechanism. After the examination of tests with 18 vessels the author decided that the detailed comparison of form and screw in a ship and its model can only be made at present on certain assumptions, and that the manner in which many trials are carried out, in particular when only one run is made each way at each speed, does not ensure accuracy. Trials run with the vessel light serve little or no particular purpose if the ship in service has its propeller well immersed. The comparison of light draught trials with model experiments show that the revolutions on the ship are higher than those predicted from the model, but the actual excess is not definite. The comparison of results with a model and a ship when well laden is fairly good, especially with twin screws, and fine-ended ships. With single-screw ships the model wakes are high compared with those of the vessel which is probably due to the fullness of the stern. This affects the hull efficiency, and to a small extent the screw efficiency. With the co-operation of builders and owners, investigations of the character of those conducted by Mr. Baker may be extended and make available a wealth of information on ship performance.

CHILEAN GOVERNMENT CONTRACTS.

Submitting tenders for supplies to foreign governments is not entirely free from unforeseen troubles. With a view to providing reliable information about the regulations relating to such matters for Chile, Mr. C. H. Bateman, His Majesty's Chargé d'Affaires at Santiago, has prepared a statement for the Department of Overseas Trade. This has been printed as a pamphlet with the title "Memorandum on Tendering for the Supply of Materials required by Chilean Government Departments." As the processes of tendering for the different departments, such as the State Railway Administration, the Department of Public Works, the Government Arsenal and the Naval Dockyards, are not identical, the information contained in the memorandum is of importance to those interested in Chilean contracts. For the State Railways, purchases are dealt with by the Material and Stores Department, Alameda Station. In this case the process of tendering has been systematised, and a publication giving the basic conditions for the acquisition of materials has been issued. Estimated requirements in each of the 29 groups, into which supplies are graded, are published in separate booklets. All tenders must, unless one is prepared to submit to a fine or forfeit consideration, be presented on prescribed forms obtainable from the Departmento de Materiales y Almacenes in Santiago, and bear stamps to the value of 5 paper pesos. The guarantee papers accompanying the tender must also be stamped at the rate of 2 c paper for each 100 pesos paper or fraction. A guarantee deposit, made out in the name of the General Director of the State Railways and equal to 10 per cent. of the total value of the tender, must accompany every tender. English banks with offices in Santiago are acceptable for the deposit. Delayed delivery may mean the imposition of a fine or the cancellation of the contract

with the forfeit of deposit. For the Public Works Department the conditions are specified in an official publication entitled "Regulations for Contracts for Public Works," but contractors must be on the register kept by the department. A cash deposit of 2 per cent. is required, which must be increased to 10 per cent. on acceptance. Naval contracts are subject to rules for tendering specified in "Nomenclature Naval," and somewhat similar guarantee deposits to those adopted by other departments are enforced. A permanent Naval Commission at 56, Victoria-street, London, receives complete information of requirements and deals with all purchases in this country.

THE AERODROME FACILITIES OF LONDON.

It has frequently been suggested that one of the causes contributing to the slow development of civil aviation in this country is the fact that the London Terminal Aerodrome is situated at Waddon, near Croydon, which is a considerable distance from the business centres of the city and is comparatively difficult of access. The question of the practicability and cost of improving the aerodrome facilities of London was therefore referred to the Civil Aviation Advisory Board, and their report to the Secretary of State for Air has recently been issued. The Board have considered the question of effecting improvements at Croydon, of making one of the other existing aerodromes near London the terminus of the air services, of developing an entirely new site, and of roofing over one of the large railway termini in London and using this as an aerodrome. The last-mentioned scheme is regarded as impracticable for the time being, and the Board's main recommendations are to the effect that the present terminal aerodrome at Croydon should be retained, but that it should be enlarged and improved at a cost not exceeding 250,000*l.*; they add, in this connection, that attention should also be given to improvements of the road communications between London and Croydon, but make no mention of possible improvements in the railway service. The possibility of transferring the terminal aerodrome to Cricklewood or Hendon has been considered and rejected. The former aerodrome is not thought to be suitable for heavy traffic, although it may be used as an auxiliary aerodrome in case of emergency. The report does not make it quite clear why the proposal to make Hendon the terminal aerodrome has been rejected. This aerodrome has several points in its favour, particularly in the matter of communication facilities with the City and West End; the Board point out, however, that it will be available as a reserve aerodrome during the next few years, in any case. Of the twelve possible new sites for aerodromes that have been considered, those at Gunnersbury Park and at Wormwood Scrubs were regarded by the Board as the most promising, but they finally decided against the latter, mainly because it was hardly large enough and would be expensive to extend. The former, however, has excellent communications which will be improved when the arterial road scheme has been carried out, since both the Great West Road and the North Circular Road will adjoin the site. Only a moderate amount of work would be involved in preparing the ground, but the site has the distinct drawback that it is situated near the river, and is therefore liable to be affected by the prevalence of river mists. In spite of this, the Board recommends the acquisition of the land, which we gather would cost about 150,000*l.*, since it might become a valuable asset in the future. It must be admitted that no financial loss is likely to ensue from the purchase of the land, even if it is not subsequently developed as an aerodrome, but, at the present time, only really essential expenditure is justifiable and it would certainly seem to us that existing aerodromes in the vicinity of London, if properly developed and organised, should be capable of meeting the requirements of civil aviation for a good many years to come; the report, in fact, actually states that, with enlargement, the Croydon Aerodrome would be able to cope with all requirements that can be foreseen at present. We therefore wish to associate ourselves with Air Vice-Marshal Sir W. G. H. Salmond, who signed the report with a proviso to the effect that the Gunnersbury Park site should be acquired only if the necessary funds are available and subject to the recommendations relating to the improvements at Croydon being first carried out.

THE INSTITUTE OF METALS.

THE fifteenth annual general meeting of the Institute of Metals was opened last Wednesday morning, the 7th inst., in the Hall of the Institution of Mechanical Engineers, Mr. L. Sumner, the president, occupying the chair.

REPORT OF THE COUNCIL.

In the annual report for the year ending December 31, 1922, the council stated that during the past year all the departments of the Institute had been busily engaged in furthering the objects for which the Institute was founded, and notwithstanding the duration of a severe trade and general economic depression, the membership had continued to increase, the number on the register on December 31, 1922, being 1,436, as compared with 1,410 in December 31, 1921. Although the membership had grown, the sum carried forward had decreased from 406*l.* 14*s.* 8*d.* to 315*l.* 6*s.* 5*d.*, as shown in the statement of accounts. By far the largest item of expenditure in the statement of accounts was that relating to the journal, a sum of 2,385*l.* 8*s.* 10*d.*, representing more than half the entire receipts from subscriptions and entrance fees. The cost of the journal averaged 600*l.* per annum in the two last pre-war years, since then it has steadily risen, reaching 2,303*l.* in 1920–21 (when the subscription was increased to 3*l.* 3*s.*). The cost of the journal for the current year was estimated to be no less than 2,700*l.*

With regard to the journal, the report further stated that the Publication Committee had paid particular attention to the Abstracts Section, and had set up a system of abstracting whereby practically the whole of the technical publications of the world likely to contain matter of interest to members were to be dealt with. Some members had urged that more "practical" papers should appear in the journal; the council would greatly welcome these.

BEILBY RESEARCH COMMITTEE.

Work on the crystallisation of metals from the solid state had been continued by the investigator, Professor Desch, in the Metallurgical Department of the Sheffield University, and a further report was in course of preparation, for presentation at the autumn meeting.

STANDARD SAMPLES OF ALUMINIUM.

Arrangements had been made for the Institute to hold standard samples of aluminium of various purities as well as certain common aluminium alloys, these to be prepared at the National Physical Laboratory, and issued on terms to be arranged to persons desirous of checking their analytical methods by reference to some agreed standard.

CORROSION RESEARCH.

The work of the Aluminium Corrosion Research Sub-Committee had been largely devoted to the study of protective coatings. Coatings of molybdenum compounds had been found to be suitable mainly for decorative purposes and exposure to atmospheric conditions only. A number of electro-deposited metallic coatings had been prepared and tested; a coating of cadmium, as produced in Professor Desch's laboratory, had given results superior to the others, but none had so far proved really efficient. At the present time the work was largely concentrated on the anodic production of hydroxide coatings, which appeared to be a promising process.

REPORT OF THE HON. TREASURER.

This stated that the expenditure continued to be in excess of what, in the opinion of the hon. treasurer, was warranted by the income. However much it would be regrettable to have to curtail the publication of papers and the reports of the discussion thereon, a way out of the difficulty has to be devised by the Publication Committee. In regard to the abstracts he ventured to suggest that the Institute should follow the example set by the Institution of Civil Engineers, who issued abstracts in a special volume only to members who were prepared to pay additionally for them. Thus the Institute's very excellent and useful abstracting work could be continued with advantage, and the cost of the Journals be very materially reduced. The council, very properly, used every endeavour to encourage young men to join the Institute as students, but he pointed out that by giving them copies of the Journal free, the Institute lost money on each student member. The provision of a superannuation scheme for the staff of the Institute was a good and desirable proposal; this matter was under consideration.

In moving the adoption of the report of the council, the chairman stated that the question of finances was a source of anxiety; a reduction in expenditure without in any way decreasing the usefulness of the Institute was not an easy matter to accomplish. In regard to the statement with reference to "practical" papers, the fact should never be lost sight of that the reading and discussion before the Institute of papers which might be styled purely technical very often led to the solution of problems that had greatly preoccupied the men in charge of production at the works.

Colonel N. T. Belaiew seconded, and the report of the council was adopted by acclamation, as also was that of the hon. treasurer.

Mr. C. C. Paterson moved a vote of thanks to the president and council for the progress made by the Institute, also for the policy which had been adopted of decentralising the Institute and encouraging activities in the provinces. That policy was the only one which would render an Institution such as theirs successful. The vote was passed unanimously.

MAGNESIUM ALLOYS.

The first paper taken on Wednesday morning dealt with "The Mechanical Properties of Magnesium Alloys," contributed by Dr. Leslie Aitchison, who read it in abstract. We reproduce it in full on page 312 of this issue.

The discussion was opened by Mr. S. L. Archbutt who found the mechanical tests quoted by the author interesting and useful. During the war, the mechanical properties of these alloys were investigated at the National Physical Laboratory, and considerable work was done with regard to their production, casting, rolling and testing. He had hoped to write a paper on that work for the present meeting, but had been compelled to postpone it for a future one. The results in the National Physical Laboratory were rather disappointing both in the case of the 6 per cent. aluminium alloy and in that of the 3 per cent. copper alloy. The results of the author might be said to be substantially in agreement with those of the National Physical Laboratory. The most prominent alloy appeared to be the 6 per cent. aluminium alloy. In the rolled sheet it gave a specific tenacity of 300, compared with 270 for duralumin and with 360 the highest value obtained for a light alloy. The author's maximum stress as cast was 10 tons; at the National Physical Laboratory they obtained 11 tons, when the elongation was 5 per cent., as against the author's 4 per cent. As wrought, the author's maximum stress was 19 tons, with 8 per cent. elongation, the corresponding figures of the National Physical Laboratory being 20 tons and 16 per cent. In the matter of the 3 per cent. copper alloy, the figures from both sources were in substantial agreement; as wrought, the author's figures were 12 tons maximum stress with 1 per cent. elongation, as against 13 tons and 3 per cent. found by the National Physical Laboratory. The latter also dealt with an 8 per cent. zinc alloy, and, as stated, found 11 tons and 6 per cent. Their figures for the Electron metal were 18 tons and 5 per cent., and for a 4·5 per cent. zinc alloy 18 tons maximum stress and 19 per cent. elongation. The author's values were very similar. The advantages of lightness of the magnesium alloys were largely discounted by the disappointingly low modulus of elasticity to which attention was drawn by the author. The value obtained at the National Physical Laboratory was lower than his, being of the order of 5,000,000 lb. per square inch. For aluminium alloys this constant was at least 50 per cent. higher. Little was known as to the fatigue resistance of strength of such alloys at high temperatures, no tests in this respect had been made so

far at the National Physical Laboratory. Pistons for internal-combustion engines containing a very high proportion of magnesium were said to have been made and successfully used in the United States. Particulars as to the behaviour of the alloys in actual use would be interesting.

Mr. H. J. Maybrey stated that mixing the metal with chloride flux allowed of melting without burning; in the foundry, however, it was difficult to produce a casting entirely free from chloride flux, whilst in laboratory practice it was possible to obtain castings relatively free of oxide and flux. An attempt was made to get over the difficulty by adding as a "dope" a small percentage of alkaline earths; these, however, whilst giving a clear casting, made for brittleness, and the old method of using flux was reverted to, when by careful treatment there were found no contamination and no flux inclusions. The piece was as clean as that "doped" with alkaline earths.

Dr. Hatfield expressed the opinion that the paper should contain the chemical analyses of the alloys dealt with, as a complement to the physical data. The remarks of the previous speaker suggested the interest which attached to the chemical contents.

Colonel N. T. Belaiew called attention to the elastic limit for the rolled strip of 6 per cent. aluminium alloy, which was in one case 5·6 tons per square inch and in another 8·2 tons, and asked for an explanation on the discrepancy.

Dr. Aitchison, in the course of his reply, agreed with Dr. Hatfield in regard to analyses; these had not been completed in time, but would be inserted in the paper in its final form. With reference to the remarks made by the other speakers, his (the speaker's) paper would lead other members to contribute their experience on the subject of these same alloys. In the matter of the elastic limit, cold-working lowered this, and subsequent heating raised it. His values represented a rather fluctuating property. The proof stress could be taken as indicative of the properties of the material. Pistons for internal combustion engines were being made of magnesium alloys, and their manufacture had been taken up in this country. They were used also in other directions, such as in pianos and typewriter manufacture, where they replaced wood, and also steel in certain parts. The magnesium alloys were not being used to any great extent in aircraft manufacture owing to their low ductility. At present they were very brittle, but it was hoped to improve them, in due course, as other alloys had been improved.

Work-Hardened Aluminium Sheet.

The second paper taken was contributed by Professor H. C. H. Carpenter and Mr. C. Coldron Smith, and dealt with "Tests on Work-Hardened Aluminium Sheet." It was read in abstract by the former; we reproduce it in abstract on page 316.

The discussion was opened by Dr. D. Hanson, who stated that tests lasting over a period of five years were undertaken but rarely, especially at high temperatures. The paper constituted a record of test results and contained nothing to criticise. He (the speaker) had done similar work on similar material, and he agreed with the authors' data on age-hardening, although he would rather give it the name of age-softening. The amount of experimental data, as the authors had said, was not sufficient to explain the remarkable changes at 200 deg. More definite conclusions could, perhaps, be given showing the influence of composition. The impurities fell in the area of Fig. 6, called X. In addition to stating that the metal was not pure, it should be said to contain some silicon, and this was more than necessary to give the constituent X. The various aluminium samples contained the same amount of silicon in solid solution, and the difference in stress was to be attributed to the silicon dissolved in solution. If X were more soluble at high than at low temperatures, a difference would be found, unless slow cooling intervened. Variations occurring in commercial aluminium were due not so much to the iron as to the silicon content. Iron in aluminium was always present as this constituent X, not as $FeAl_3$.

Colonel N. T. Belaiew emphasised the importance of long duration tests such as those carried out by the authors.

Mr. W. B. Clarke stated that for the purposes of his works he had to obtain aluminium and also other metals of absolute purity. He asked in what way the authors had melted and treated their aluminium. Was it melted with coke or gas-fired furnaces to the exclusion of air. Oxygen caused great trouble; sulphur also where coke and gas were used. The crucible itself might lead to impurities in the metal. Non-ferrous crucibles were now available, the use of which led to no iron from them entering the metal. Using gas and ordinary crucibles, even if these were closed tight, might give trouble, as the crucibles were porous and sulphur might be taken up by the metal. Did the authors heat-treat their sheets in a non-oxidising atmosphere? The drawing down of metals to fine wires, as he (the speaker) did in his establishment, was a test which really did show whether a metal was pure or not.

Mr. C. C. Smith, in replying briefly, and with reference to Dr. Hanson's remarks did not think that the constitution of the metal offered a solution to softening at higher temperatures than 250 deg. where re-crystallisation came in. In tests where re-crystallisation had taken place, the size of crystals rose with the purity of the metal. In reply to Mr. Clarke, the aluminium was supplied by the Aluminium Company and was the purest available. The treatment of the sheets was described in the first paper, by Professor Carpenter and Mr. L. Taverner. The metal was heated by gas in a closed oven, and the metal could suffer no ill-effect from the gas; after five years it was as bright and polished as when first put in.

Amalgams.

The third paper had reference to "Volume Changes Accompanying Solution, Chemical Combination, and Crystallisation in Amalgams," by Dr. Arthur W. Gray, Caulk Dental Research Institute, Milford, Delaware, U.S.A. A *précis* of this was given by Professor Turner. It is of a nature which does not lend itself to a brief abstract.

Mr. A. E. Smith stated that a large amount of work had been done during the last ten years on amalgams, but a large part of it was unscientific. The authors' contribution was a most excellent one, and one which would advance our knowledge of dental amalgams. The size of the alloys for amalgamating was an important item. He (the speaker) said he would contribute further to the proceedings on this question by correspondence.

Professor Turner said that accurate work had been carried out recently in England in this field, by Professor McBain and others, named by the author. Professor McBain had been appointed a Fellow of the Royal Society a few days ago, no doubt due to his researches on amalgams.

Aluminium-Copper and Nickel Alloys.

The fourth paper, by Miss Kathleen E. Bingham and Dr. J. L. Haughton, dealt with "The Constitution of Some Alloys of Aluminium with Copper and Nickel." It was read in abstract by Dr. Haughton.

The paper covered a very complete investigation of the ternary system copper, nickel, aluminium, up to 12 per cent. copper and 10 per cent. nickel, and gave the thermal analysis, electrical resistance measurements, microscopic examinations, &c.

In opening the discussion, Dr. D. Hanson found that the authors had been successful in their carrying out of a very difficult research, the ternary system being a most complex system, much more so than the binary system. At one part of their paper the authors stated that at about 450 deg. $CuAl_2$ was deposited from solution, probably from the ternary body; there was then no further change down to 200 deg. This statement as it stood was rather misleading; it was difficult to determine the liquidus, and that in his (the speaker's) opinion would account for many of the arrest points in the authors' curves.

Professor Carpenter emphasised the remarks made by the last speaker and called attention to the very large number of ternary alloys.

Dr. Haughton agreed with Dr. Hanson's remark and the above phrase, it should have been stated that there was "no further phase change." In regard to the curves, segregation caused all the trouble, but they were not clear as to how segregation worked. The alloys were stirred vigorously, and it was a curious fact that the stirred alloys did not show any liquidus point. Some points in the curves were due to metastable constituents. They had examined about 60 alloys in all, and had taken curves of all the different systems.

Cold-Worked Cadmium.

The last paper taken at the meeting on Wednesday morning dealt with "The Recrystallisation of Cold-Worked Cadmium," by Mr. M. Cook, Cambridge. It gave data on the recrystallisation of the rolled metal, on deformation by compression. In the absence of the author, the paper was not read.

Dr. D. Hanson, who opened the discussion, said he thought the author's results could be explained more correctly and simply by reference to the constitution of cadmium, on the allotropic theory than as stated in the paper. He differed from the author in regard to several of the latter's statements with reference to his micrographs.

Professor Carpenter stated that there were changes in specific gravity and in Brinell hardness, there were also the recrystallisation effects, three independent changes, all pointing to the same evidence, an evidence which was overlooked by the author.

This concluded the proceedings of the first meeting.

Annual Dinner.

The annual dinner of the Institute was held at the Trocadero Restaurant on Wednesday night, a large number of distinguished guests being present. The members and guests were received by the president. The health of the Institute of Metals was proposed by Sir Thomas Holland, K.C.S.I., F.R.S., rector of the Imperial College of Science and Technology, and in reply the chairman referred to the growth of the Institute, which now had a membership of 1,400, or more than double the pre-war figures. The toast of "Kindred Societies," was proposed by Professor T. Turner, who mentioned that the origin of the Institute was largely due to the Institution of Mechanical Engineers, whose members had always shown great sympathy with their work. Mr. S. J. Speak, President of the Institute of Mining and Metallurgy, mentioned humorously that his Institute did not regard the work of the Institute of Metals as coming under the head of metallurgy, and so there was no jealousy. Sir Gerard A. Muntz, past-president, proposed the health of the guests, which was responded to by Major-General Sir Sefton Brancker, K.C.B., director of Civil Aviation, and Sir Richard Redmayne, K.C.B., K.C.M.G., chairman of the Imperial Mineral Resources Bureau.

(To be continued.)

AN IRRIGATION PROJECT OF THE CALIFORNIAS.*

By Sydney Lionel Rothery, Assoc. M.Inst.C.E.

The reclamation of 940 square miles of the Colorado desert has been achieved in 20 years by the development of an irrigation project, the water-supply for which is diverted from the Colorado river, where it crosses the international boundary between the United States and Mexico. The project is partly in California of the former country and partly in Baja California of the latter. The soils are the alluvium formation of centuries from the silt-laden waters of the Colorado river emptying into a low-lying basin, which is 250 ft. to 275 ft. below sea-level at its northern end, where the Salton sea now lies, and which is topographically an extension of the great trough of the Gulf of California.

A natural diversion of the river into this low-lying valley, submerging the whole area of the project, would now be taking place were it not for the operations of American engineers, who have built and maintained over 60 miles of training-levees that guide into the gulf the unused flow of the river and the waters stored up behind them during flood periods.

The heavy depositions of silt annually laid down behind these levees have caused a raising of the ground and of the river itself that is still in progress; and continual heightening and strengthening of the levee system has been, and is being, done to assure the flood-protection essential to the existence of the project. A river-diversion is being undertaken behind the levee system, and, if successful, this will bring relief for some years from the present anxiety and heavy annual expenditure.

The growth of the project is shown by the census returns of 1920 and by the statistics of agriculture produce for the same year. The valley is now supporting 50,000—60,000 persons, whereas in 1900 no white men were resident there. The chief field-crops are cotton and its by-products, valued at 23,957,000 dols. for 1920; canteloupes at 9,208,000 dols.; grain at 5,007,040 dols.;

* Abstract of a paper read before the Institution of Civil Engineers on March 6, 1923.

livestock at 4,752,000 dols.; butter at 3,377,000 dols.; also alfalfa, barley, maize, and fruits.

The jurisdiction is controlled by "The Imperial Irrigation District," a municipal corporation with elected directors for controlling the diversion of the water for irrigation from the river and that portion of the project in the United States. The Mexican portion is nominally controlled by the "Compania de Terrenos y Aguas de la Baja California, S.A." which is virtually the Imperial Irrigation District operating in Mexico, necessarily complying with Mexican statutes and tariff rates fixed for water-charges.

The characteristics of the lower Colorado river are maximum floods of 180,000 cub. ft. per second, to 220,000 cub. ft. per second, the minimum discharge being as low as 2,700 cub. ft. per second. The maximum and minimum yearly volumes are 25,967,577 acre-ft. and 7,959,000 acre-ft. There is a regular flood each May and June, due to melting snows in its upper watershed, and high floods of short duration sometimes occur in the winter months of January and February, due to rains in Arizona. The watershed of the river drains 242,000 sq. miles.

The erosion and transportation of silt in suspension and of bed sand in the channel are well-known features of this turbid river, the suspended matter ranging between 1,500 parts and 22,400 parts per million on monthly values, estimated by averaging many samples: 13,000 acre-ft. of silt are transported annually as suspended matter. The river scours and refils its channel to as much as 20 ft. deeper than normal with the passing of its floods.

Where the transportation of bed sand and the variation of river-bed elevations are so marked, diversion conditions for the project with such a turbid water-supply necessarily require (1) a weir across the river, which has to be removed before each high flood—a condition imposed by the surrounding farmers or townspeople; (2) an overpour skimming type diversion intake-gate, operative at varying heads to keep out as much bed sand as possible; and (3) dredging operations below this gate to remove as much sand as possible, before it enters the main canal-system.

The diversion-weir is made by immersing a number of wedge-shaped brush-mattress units side by side from a cableway spanning the river, the principle causing the submergence being the pressure due to the velocity of the stream against their inclined surfaces. Steel cables are attached to each unit and anchored to pile-dolphins driven across the stream. The deposition of silt, due to the obstruction of the stream, fills the interstices of the brush and builds a weir to maintain sufficient entry head over the sill of the intake structures.

The canal-system requires higher velocities of flow than is usual for self-maintaining canal sections; and Mr. R. G. Kennedy's formula for critical velocities as used in India would give too slow velocities to prevent silting—the coefficient 0·84 should be changed to about 0·98 to be applicabie, the formula thus becoming $V = 0{\cdot}98\ D^{0{\cdot}64}$. Aquatic growth and grass berms forming in the canals and laterals are most troublesome and necessitate much cleaning to maintain capacities. The value of N (Kutter) would be under 0·020 were it not for the aquatic growth; the actual values are between 0·021 and 0·029, and for design calculations, 0·0225 is used. The quantity of silt diverted into the canal-system in 1920 was 15,139 acre-ft., and in 1921, 12,738 acre-ft.

The canal structures are of timber and reinforced concrete. Automatic radial gates are extensively used, and the structures are built for capacities up to 8,000 cub. ft. per second. Both hand-wheel geared lifts and engine-driven mechanism are used for raising vertical lift gates.

The soils are sedimentary fine silts, compact and heavy, requiring much cultivation to maintain their proper physical condition. They are devoid of humus, although the necessity for applying commercial fertilisers does not generally exist. Continuous irrigation, and seepage from canals for several years in some localities, have produced a water-table too close to the ground surface, and an extensive system of open deep drains is being commenced to release the underground water that has already damaged over 120,000 acres.

The water-duty for cotton-growing is 3·70 acre-ft. per acre each year, and for the diversified field-crops 3 acre-ft to 4·08 acre-ft. is attained. An average cost, over a period of five years, 1916 to 1920, to the American farmer for water was 5·58 dols. per acre. The quantity of water diverted for the whole project in 1920 was 2,821,543 acre-ft., and for 1921, 2,421 580 acre-ft.

SOME PROBLEMS CONNECTED WITH THE RIVERS AND CANALS IN SOUTHERN INDIA.*

By JOSEPH MELVILLE LACEY, M.Inst.C.E.

THE paper deals with some problems depending directly or indirectly on the transporting power of flowing water, which arise in connection with the large rivers of Southern India, more especially in their lower reaches. The conditions of the flow of water down these rivers during the dry weather and during floods are described. The author points out that, from a series of surveys of a river-bed taken every dry season, noting the "live channel," blind or extinct live channels, creeks, and the shape of the sand shoals separating them, it should be possible to predict probable changes in the river-channels, and the movement of the sand shoals, which should give an indication of the retaining-works to be constructed or the dredging necessary to preserve the live channel in its regular curves, and to prevent it attacking or hugging either river-margin. Bank-erosion is attributed chiefly to the ground water of the saturated river-margin. When the support of the flood water against the margin is withdrawn during a falling flood, ground water flows into the river, carrying with it particles of soil which are swept away by the current, thus causing hollows, with the result that the margin caves in. The erosive action of the current has also some effect on the margin. A falling flood carries less silt than a rising one, and therefore its power of transporting material and its erosive action is greater.

A deflecting force, due to the earth's rotation, acts on rivers, more especially when they flow in a north and south direction. Instances are given of the erosion of river-margins, of rivers leaving their old courses and taking new ones, and of the general trend of the flood waters in a river, as examples of the possible action of such a force.

The results of constructing longitudinal flood embankments in the deltaic reaches of a river are indicated. In the case of a river which normally spills its banks during floods, if, after levees are constructed, the cross-sectional area of the tidal reach is insufficient to discharge the whole flood, the tendency would be for the river-bed to rise, and the range of tidal influence would suffer diminution. If, on the other hand, the tidal reach is more than sufficient to discharge the whole flood coming down the river, the effect of the levees would not be so marked. Scouring of the river-bed would occur during a falling flood, so as to reduce or annul the rise of bed caused by the rising flood, and the tidal range would be also increased.

Silt or sand carried into the irrigation-canals of South India is of a heavier and coarser grain than that of the sands of North Indian rivers; it is more often rolled along the bed of the stream than carried in suspension. An anicut, or low dam, built across a river in order to hold up low water supplies, causes the river-bed to silt up almost to the crest-level of the anicut, unless the velocity in the river is sufficient to scoop the sand over it. This causes an increased deposit of silt in an irrigation-canal taking off from the river upstream of the anicut. To prevent this rise of the river-bed, the later anicuts are built in the shape of vented dams, with their vents closed by roller-bearing shutters; their action on the river-bed has not been so satisfactory as was anticipated, and more experience in their working seems necessary before they can be said to have solved the silt problem in irrigation-canals. The use of a curved anicut built diagonally across a river, so as to cause a scour at the down-stream flank, is suggested.

* Abstract of a paper read before the Institution of Civil Engineers, March 6, 1923.

THE INFLUENCE OF SILT ON THE VELOCITY OF WATER FLOWING IN OPEN CHANNELS.*

By ARTHUR BURTON BUCKLEY, Jun., O.B.E., Assoc.M.Inst.C.E.

EXPERIMENTERS in hydraulics have observed from time to time variations in the velocity of water corresponding with variations in its silt content, while other factors remained the same. Messrs. Ganguillet and Kutter endeavoured to obtain a constant coefficient for any given channel, but found that the coefficient varied in the same channel. In 1918 the Egyptian Government commenced systematic current-meter gaugings of the Nile, which showed similar variations. Owing to the complexity of the problem there was some hesitation in accepting certain conclusions, but a machine had in the meanwhile been developed, known as the Buckley-Wilson discharge-recorder, which, operated electrically by two special transmitters at float stations 5 kilometres apart on the Menufia canal, automatically combined the surface slope and depth, &c., according to Kutter's formula. This instrument was found to give irregular readings. The discharges recorded, although generally correct, were too low at times, and are shown to coincide with the arrival of silt-laden water. The possible influence of the silt on the velocity is explained.

The systematic gaugings of the Nile, begun in 1918, were continued in 1919–20–21 in the same reach of the river at Khannaq and Baqlawis, about 35 km. downstream of the Assuan dam. Furthermore, in 1921 an additional series of gaugings, together with silt measurements, were made at Beleida about 38 km. upstream of Cairo. These gaugings consisted in measuring the hydraulic elements, *i.e.*, the velocities by current-meter, taken at about six different depths at about twelve position buoys ranged across the river, the surface slope, the hydraulic radius, the sectional area, and the discharge. The silt quantities were determined from samples drawn from four different depths at each of six positions marked by buoys in the river. At the Khannaq and Baqlawis stations 480 sets of gaugings were made, and at Beleida 182 sets. These and other gaugings and silt measurements in the Nile and Menufia canal are examined. The groups of elements for the different seasons covering the rising and falling stages of the river are plotted against the surface levels as common ordinates, and by these and other curves irregularities of velocity and discharge compared with surface slope and other governing factors are pointed out and their cause discussed. Instances are given which show considerable abnormal variations in velocity at intervals of only a few days, such as the following:—

Date.	Mean Velocity.	Slope at site.	Hydraulic radius.	Level of river.
	M. per sec.	Cm. per Km.	Metres.	R.L.
12th October ..	1·213	7·5	8·23	86·685
14th " ..	1·075	8·0	8·04	86·36

Reducing the velocity measured on the 14th to suit the slope obtaining on the 12th it becomes 1·041 m. per second, which is a reduction of 14 per cent. on the velocity measured on the 12th, although the difference in hydraulic radius would not account for more than 2 per cent. This irregularity in flow is traced to the regulation on the Assuan sluices producing a change in the silt carried in the water.

Variations in cross section of the Nile also coincide with periods when the discharge of the river is varied by regulation on the Assuan dam. General formulas for flow of water in open channels are stated, and it is shown that the variations in velocity are such as to point to the influence of a new factor hitherto absent in hydraulic formulas.

Further characteristic examples of abnormal velocity-fluctuations are discussed for the Khannaq discharge-station in 1920. It is shown that they correspond with silt-variations, and that these again correspond with variations in sluice-openings in the Assuan dam. Considering discharges at Khannaq in 1921, the varying slope of the water-surface of the river between the rising and falling periods is discussed; characteristic points on the curve correspond with variations in discharge brought about artificially by the manipulation of the Assuan sluices. A particular change in direction of the velocity curve which appears in each year is shown to correspond with the arrival of silt with the flood waters.

The increase in velocity of the Nile, observed at the Beleida station, near Cairo, between August 13 and August 22, 1921, is shown to be greater than can be explained by variations in the factors included in the usual formulas. Examples are given of irregular discharge in canals referred to definite levels.

A striking example is given of the effect on the flow of the Menufia canal which irrigates about 1,000,000 acres in the Delta. From August 18 to August 27, the period of silt-precipitation, the level at the head gauge was 15·40, the slope was 5 cm. per kilometre, and the measured discharge was 258 cub. m. per second. On November 25, when silt had practically disappeared from the water, with the same level and slope the measured discharge was only 214 cub. m. per second, or 17 per cent. less than in August. In order to discharge 258 cub. m. per seconds in November, it would have been necessary to increase the depth of water in the canal by 0·53 m.

Finally, a new formula, which includes a silt factor, is put forward for computing the velocity of the Nile from observations of slope at the Beleida discharge-station. Whereas established formulas, such as Kutter's, Bazin's and Manning's, give values which, during the flood period, vary from the true values by as much as 50 per cent., the new formula—known as the Beleida formula—gives very much closer results. In order to test the general applicability of the formula to other reaches of the Nile, it has been applied to the Khannaq discharge-station in 1920. The results obtained are in close agreement with the observed velocities.

Although the silt factor included in the formula is the amount of silt actually in suspension in the water, allusion is made to the fact that this may only be a measure of the true agent in the phenomenon as contrasted with the phenomenon itself; hence stress is laid on the importance of confirming the results obtained in the Nile with results which might with advantage be collected in other rivers. There appears to be little doubt, however, as to the necessity of including a factor in velocity formulas corresponding with the solid matters carried in suspension by the water.

* Abstract of a paper read before the Institution of Civil Engineers, on March 6, 1923.

FILTRATION THROUGH MOVING SAND.—The early waterworks filters were all of the slow sand gravity type, but though they were highly effective as regards the purity of their effluent, they have been almost entirely superseded by high-speed, rapid or mechanical filters on account of the enormous saving of space effected by the latter type. In the mechanical filter as the term is ordinarily understood, the sand is stationary, except during the periodical washings, when it is violently agitated either by a reverse flow of water or by compressed air. Washing has to be carried out at intervals of twenty-four hours or less, according to the impurity of the water, and during the washing as well as for a short time afterwards, the filter has, of course, to be withdrawn from service. To obviate this frequent washing and the consequent disturbances of the filtering efficiency, a type of rapid filter was devised several years ago, in which washing proceeded continuously. In this filter, which was known as the Ransome drifting sand filter, the sand surface is of a conical form, the sand slowly drifting from the apex to the periphery all the time. It then descends by a number of pipes to a washing chamber where it is washed and returned to the apex of the cone by a central pipe. The filtering surface is thus maintained in a high state of efficiency and thorough washing is only necessary at intervals of from six to thirty days, according to the state of the water. The largest drifting sand filter installation yet put into service is at Toronto, where 72,000,000 gallons of water are dealt with daily by the plant. This was put down by the Municipal Authorities in consequence of the highly satisfactory results obtained from a trial filter constructed on the same principle to deal with 500,000 gallons per day. There are now in Canada eight drifting sand filter plants in operation, and others are in service in France, Jamaica, Brazil, &c. Although an English invention, the merits of the drifting sand principle have received little recognition in this country. The manufacture of filters of this type has, however, now been taken up by Messrs. Vickers, Limited, of Broadway House, Westminster, and it is likely that the drifting sand filter will come into more extended use.

THE MECHANICAL PROPERTIES OF MAGNESIUM ALLOYS.*

By LESLIE ARCHISON, D.Met., B.Sc., F.I.C., Member (Birmingham.)

THE desire of constructors of internal-combustion engines to obtain the lightest possible reciprocating parts has caused a considerable amount of interest to be taken in the alloys of magnesium for the manufacture of such parts. The lightness of the alloys also makes them very attractive to constructors of the different kinds of aircraft. In view of the interest that has been aroused in these alloys, some investigation has been made of the mechanical properties of the various kinds of alloy. It is considered that a note on these mechanical properties may result in the dissemination of information with respect to magnesium alloys which will be of use to various people.

Tests have been made upon Electron metal supplied by the Sterling Metal Company, and also upon various other alloys of magnesium which have been manufactured by the Magnesium Company Limited. The materials have been tested in a variety of conditions. Some of the specimens were in the cast condition, some of them had been rolled into strip, others again had been extruded, whilst others were hot forged.

The alloys contained only one element in addition to magnesium. The alloying elements were copper, aluminium in different proportions, and cadmium. This statement does not refer to the Electron metal, which was not analysed †

The cast test-bars were cast in chill moulds and machined to size. The moulds, however, were heated to a fairly high temperature prior to casting, with the result that the chilling effect on the alloys was not very intense.

The proof stress has been determined in accordance with the British Engineering Standards Association's requirements for light alloys.

Electron Metal.—This metal was tested in the form of an extruded round bar of 1½ in. diameter, and an extruded rectangular bar 1½ in. × $\frac{11}{16}$ in. The mechanical properties of these specimens were as follows :—

	Round Bar.	Rectangular Bar.
Elastic limit, tons per square inch ..	4·4	6·4
Proof stress, tons per square inch ..	14·6	11·3
Maximum stress	17·6	16·1
Elongation per cent. (on $l = 4\sqrt{\text{area}}$) ..	11·0	12·5
Reduction of area, per cent.	13·4	16·3

1 *Per Cent. Cadmium Alloy.*—This alloy was tested in the following conditions :—(1) "as cast" in hot chills ; (2) in the form of a forged square bar ; (3) in the form of a rolled strip (0·041 in. thick) ; and (4) in the form of an extruded rod about 0·125 in. diameter. The forged bar was tested in the forged condition without any heat-treatment. The rolled strip was heated to 300 deg. C. for a brief time before testing. The tensile tests on these various specimens gave the following results :—

Condition.	Elastic Limit. Tons per Sq. In.	Proof Stress. Tons per Sq. In.	Maximum Stress. Tons per Sq. In.	Elongation per Cent.	Reduction of Area per Cent.
Cast bar ..	1·2	2·86	4·4	3·5 ($4\sqrt{A.}$)	3·1
Forged bar ..	—	11·3	14·1	5·0 ($4\sqrt{A.}$)	6·9
Rolled strip ..	5·8	11·2	11·6	1·0 (2 in.)	—
Rolled strip ..	5·8	11·2	11·4	0·75 (2 in.)	—
Extruded rod ..	—	—	11·5	—	—
Extruded rod ..	—	—	9·7	—	—

6 *Per Cent. Aluminium Alloy.*—This alloy was tested in three conditions :—(1) "as cast" in hot chills ; (2) as rolled strip (0·102 in. thick), after heating to 300 deg. C. for a brief time ; and (3) as a thin extruded rod. The results of the tests in these various states were as follows :—

Condition.	Elastic Limit. Tons per Sq. In.	Proof Stress. Tons per Sq. In.	Maximum Stress. Tons per Sq. In.	Elongation per Cent.	Reduction of Area per Cent.
Cast bar ..	1·78	5·44	9·1	5·0 ($4\sqrt{A.}$)	4·55
Cast bar ..	1·8	5·3	9·8	4·5 ($4\sqrt{A.}$)	4·6
Rolled strip ..	5·6	16·6	18·5	7·5 (2 in.)	—
Rolled strip ..	8·2	17·1	18·3	8·0 (2 in.)	—
Extruded rod ..	—	—	18·7	—	—
Extruded rod ..	—	—	19·6	—	—

13 *Per Cent Copper Alloy.*—This alloy was tested in the cast condition (in hot chills), and gave the following test results :—

Elastic limit, tons per square inch ...	2·0
Proof stress, tons per square inch ...	7·4
Maximum stress, tons per square inch ...	7·6
Elongation per cent. (4 $\sqrt{\text{area}}$)	0·75
Reduction of area, per cent.	0·36

* Paper read at the meeting of the Institute of Metals, on Wednesday, March 7.

† See ENGINEERING, vol. cxii, page 641.

11 *Per Cent. Aluminium Alloy.*—This material also was tested only in the cast condition (in heated chills), and gave the following results :—

Elastic limit, tons per square inch ...	2·0	2·0
Proof stress, tons per square inch ...	8·6	8·3
Maximum stress, tons per square inch	9·3	8·55
Elongation per cent. (4 $\sqrt{\text{area}}$) ...	1·0	1·0
Reduction of area per cent.	0·36	0·32

3 *Per Cent. Copper Alloy.*—This material was tested only in the form of rolled strip, which was heated to 300 deg. C. for a brief period before testing, and gave the following results :—

	(1)	(2)
Proof stress, tons per square inch ...	10·3	
Maximum stress, tons per square inch	10·9	12·0
Elongation per cent. (2 in.)	1·0	1·0

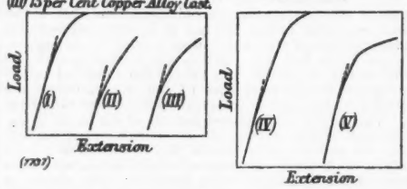
The modulus of elasticity is approximately the same in all the alloys tested, at a value of 2,800 tons per square inch.

A selected number of load/extension diagrams are

LOAD/EXTENSION CURVES.

Fig. 1.
(I) *6 per Cent Aluminium Alloy Rolled Strip.*
(II) *11 per Cent Aluminium Alloy Cast.*
(III) *3 per Cent Copper Alloy Cast.*

Fig. 2.
(IV) *Electron Metal Extruded Round Bar.*
(V) *Electron Metal Extruded Rectangular Bar.*



given in Figs. 1 and 2 to illustrate the form of curve given by the various materials.

The main conclusion to be drawn from the various tests is the great superiority as regards mechanical properties possessed by the alloys that have been worked —whether hot-worked by forging or extruding, or also cold-worked by strip rolling.

The mechanical properties of the alloys have no definite theoretical interest. The test results do, however, indicate what can be expected from these alloys by anybody who wishes to incorporate them in any engineering structure. In general, it is the aircraft engineer who might be expected to be interested in such light materials. It is a little doubtful whether for his purpose the alloys really are effectively light, in view of their low elasticity and not conspicuously good mechanical properties. The slightly heavier alloys of aluminium are much better in both respects. Better properties in the magnesium alloys may follow from their further development.

SOME MECHANICAL PROBLEMS IN THE RUBBER INDUSTRY.*

By H. C. YOUNG, Associate Member.

(*Continued from page* 284.)

Canvas and Fabric Spreading Department.—The material for the various purposes is received in rolls 48 in. to 84 in. width, and from 50 yards to 300 yards in length, which weigh up to 500 lb. The transport of the material through the various processes presents a problem calling for the closest attention. In addition to the weight and bulk of the material itself there is that of a lining of similar length and width which must be introduced during the rubbering process to prevent the treated surfaces adhering when the material is rewound or batched on a roller known as a "box roller." This lining remains in the material until the fabric is finally introduced into the tyre, shoe, hose, &c., as an integral part.

The rolls are usually man-handled, and transported by electric trolley from operation to operation. The linings pass through all the processes and return to the starting point. If they become torn and dirty, or if rubber adheres to them, they must be dealt with in a repairing and cleaning section. The weight of a 72-in. roll of cotton tyre-duck is approximately 500 lb., and after the various soaking, spreading and calendering operations this is increased by a further 500 lb. together with the lining which is about 300 lb. ; the total weight with the "box" roller (100 lb.) is approximately 1,400 lb. Since this roll must be weighed after each stage, suitable weighing apparatus must be installed, usually of the crane hook type, fitted where overhead runways are made to pick up and feed machines. By arranging stocking rails at the correct height, and suitable for carrying the "box roller" which should be standard for any given equipment, hand lifting is not necessary. Electric and hand trolleys can be fitted with a saddle which, when butted up against the stock rails, allows the bale of material to be rolled on or off the trolley. So by a judicious arrangement of the three methods, ease of handling of the heavy rolls is possible. The above system of stock rails keeps the material and lining clear of the floor. Should it rest on the floor after rubbering, the material would stick to the lining. This would result in a ruined product.

The order of progress for rubbering cotton material is : (1) Linings ; (2) dough and solution making ; (3) soaking or impregnating cotton materials ; (4) spreading of cotton materials ; (5) drying and warming of canvas for frictioning ; (6) calendering, namely, topping, or skin coating and frictioning.

It is not always necessary to go through every one of the above operations.

Linings.—The present practice in cleaning is to pass the lining over an exhaust vent working with a 5-in. vacuum, which frees it of dust and most of the loose foreign matter. This method has been introduced as an alternative to brushing the linings with a view to reducing the labour and wear due to brushing. The vacuum pipe is somewhat of a failure, as it removes only the surface dust ; and the lining is held so tightly against the vacuum opening that the wear is greater than that of a brush. It is interesting to note that 12 lb. of fine dust are collected per 20,000 yards of 72-in. lining. If a tacky quality of stock has been used, the lining may be returned to the lining section with large patches of rubber adhering to it throughout the length, and it cannot be used again until these are completely removed. The lining must be repaired when torn, and requires for this work a sewing machine. The old practice of removing the lining from a batching up machine can be obviated by the use of a travelling sewing machine which is capable of sewing and travelling across the material, and such a machine as used in the textile trade will give very satisfactory results. It is essential that the material should be batched up square on the box rollers, otherwise the linings would not cover the rubbered surfaces of the cotton fabric ; since it is not easy to box 300 yards to 400 yards of cloth centrally on a box roller, the ingenious device of the Foxwell guide is used.

Dough and Solution Making.—The method of dough and solution making is to take the mixed rubber from the mill and to sheet it out, and soak in a solvent, such as naphtha, for a period of 24 hours, after which it is churned in a hopper by paddles, until it reaches the desired consistency, further quantities of the solvent being added from time to time. Measurement and supply of solvent, filling and emptying the hoppers, are the problems to be dealt with, and though the plant is simple the main consideration is one of detail improvement rather than of radical change. The old method, which is to a large extent still employed, is to receive the solvent in drums, from which supplies are drawn in buckets, the measurement being done in quart or gallon measures. Such a system with a volatile liquid is bad because of the enormous waste of solvent, vitiation of atmosphere, inaccurate measurement, and risk of fire. The latest practice in handling solvent is by a pipe system from the rail or road wagon tank, discharging direct to the storage tanks and from there to each machine or hopper. There are three methods generally used for lifting and distributing the solvent from the storage tank, namely :—

(*a*) Pumps. Rotary pumps in practice are unsatisfactory because of the leakage of liquid at stuffing boxes, &c., and a good naphtha pump does not yet appear to be available. Those in use do not stand up to the wear and tear demanded by ordinary factory conditions and are not reliable for lifts of considerable dimensions where a long length of pipe line is in use.

(*b*) Hydraulic systems offer some advantages, but are not sufficiently "fool-proof" for general works use. There is danger of mixing water with the solvent which has a highly deleterious effect on manufacture.

(*c*) The use of compressed air or inert gas is probably the simplest and best means of lifting the solvent, and the system is fireproof. The chief disadvantage is the time required to get up the necessary pressure (approximately 10 lb. per square inch) in a large tank containing naphtha. The whole system being under pressure, is also liable to leakage.

Measuring of Solvent.—The old method, that of measuring by hand into calibrated buckets or gallon or half-gallon measures, is slow and wasteful. Meters are now available, but they are mechanically too delicate to stand up to continuous working, and are not reliable for measuring small and intermittent quantities. The measuring pump is also inadequate for use on long lines.

Sheeting and Letting Down, or Steeping Rubber in Solvent for Dough and Solution.—This operation is still manual, and a satisfactory mechanical alternative has not yet been evolved. It is necessary to soften the rubber sufficiently for subsequent operations, the method found most suitable being to mill the rubber into thin sheets on a sheeting mill and to lay it in solvent boxes from 12 hours to 24 hours. Some of the most recent mechanical attempts to do this failed because no means were provided for removing the static electrical charge before the rubber reached the naphtha.

Mixing of Steeped Rubber into Dough and Solution.—The old method of performing this operation was to work the rubber and naphtha after letting down for 24 hours in solvent, on rolls similar to mixing rolls, which were fitted with scrapers, and the dough worked until the product was homogeneous. This method meant higher power consumption and greater evaporation loss, but the quality of the product is decidedly superior to the one obtained by the modern method of using enclosed hoppers which have the disadvantage of allowing

* Paper read before the Institution of Mechanical Engineers, on Friday, February 16, 1923.

Note.—In connection with Table III. of this paper, reproduced on page 249 *ante*, the author has requested the addition of the following note :—The three automatic mixing machines (Farrel, Perkins and Banbury) mentioned in Table III. are rather difficult to compare as to size, but the Perkins and Banbury machines were approximately of the same size, while the Farrel machine is a single-rotor machine having, in this instance, a rotor about 8 per cent. larger than either of the other two. These figures were taken out some time ago, and at the present time each maker can quote much improved figures.

lumpiness and powder caking. The mill method is still much used. The requirements of a good dough-mixing machine (Fig. 23) are: (*a*) Solvent-proof glands to shafts, &c.; (*b*) easy and complete removal of finished dough; (*c*) rapid and smooth working up of dough without undue generation of heat; (*d*) tight-fitting lids to avoid loss of solvent by evaporation; (*e*) low horse-power consumption; (*f*) no necessity for skilled labour; (*g*) low maintenance cost. There are two main types of solution hoppers known as the duplex or scythe type, and the propeller type. Both are good, but the duplex is the superior for the following reasons: (*a*) The duplex hoppers are fitted with a two-speed gear, which enables a greater output per machine to be produced; (*b*) after a batch is mixed, the hopper can be emptied much more

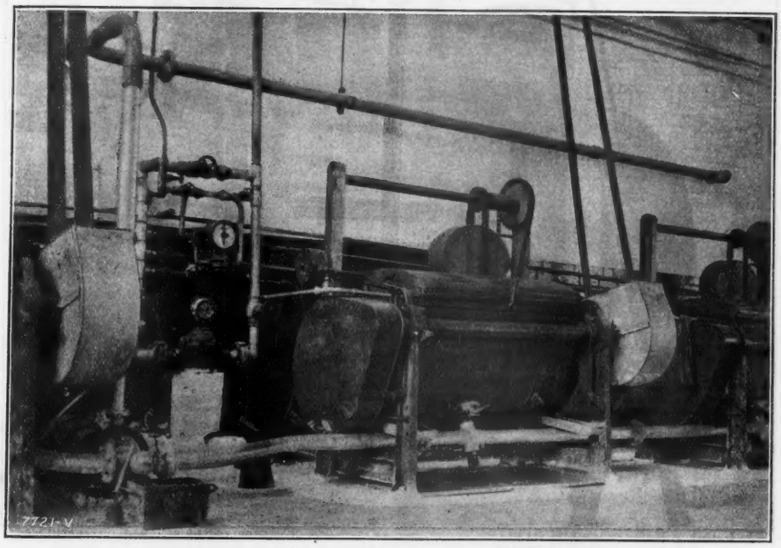


FIG. 23. DOUGH-MIXER AND SOLUTION HOPPERS WITH PUMP MEASURING APPARATUS.

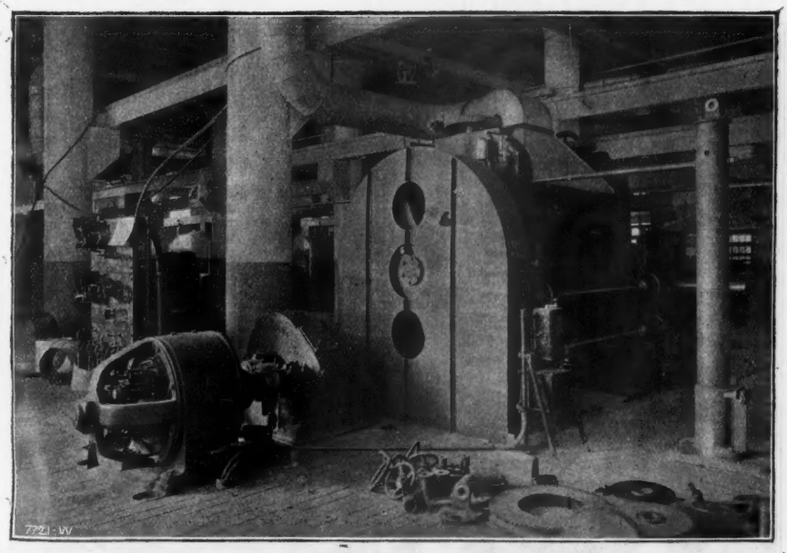


FIG. 24. AMERICAN CALENDER ROOM, SHOWING HOODS OVER CALENDERS.

quickly owing to the type of blade: (c) easier to clean out; (d) powders do not clog round the blade, as they do with the propeller type. There is undoubtedly scope for a machine using a combination of the dough mill and the hopper, which might successfully embody the best features of both machines. The cooling of the machine and blades might also be undertaken.

Transportation of Dough and Solution.—The transport of dough, such as is used for spreading tyre-ducks and garment proofings, presents no special problems, as a pipe system is out of the question. It is most convenient to transport it in boxes, with well-fitting lids provided to prevent solvent evaporation. For conveying rubber solution to impregnating or soaking machines, spreaders, packers, &c., pipes have been used in America, but are not used in this country, with one, or perhaps two, exceptions. The advantages of such a system are many, including low labour cost, diminished evaporation losses, increased cleanliness and less vitiation of the atmosphere.

Impregnating (Soaking).—Impregnating or soaking canvas fabric, &c., in rubber solution is principally confined to tyre work, where the cotton used for carcases, &c., is packed and insulated with rubber to minimise chafing.

Soaking.—Every manufacturer apparently has installed plant to his own ideas, and very few standard machines are in use. The best known is the Continental type, the main features of which are: (1) Enclosed dip bath; (2) adjustable driven rollers for squeezing surplus solution out of cloth; (3) drying operation continuous with soaking; (4) naphtha vapours carried off by air current circulating round enclosed circuit, consisting of evaporating and condensing portions; (5) condenser system for recovery of solvent at atmospheric pressure. The disadvantages of this system are: (1) Low solvent recovery, averaging about 65 per cent. of the solvent fed into the dip bath; (2) low output owing to very low speed of operation. Normal running speed is two cloth yards per minute.

The American plant for impregnating introduces several new features; (1) Two dip tanks are arranged in series so that two soaks can be given at one run; (2) the whole of the soaking and drying is carried on in an enclosed chamber, in an atmosphere of inert gas, such as flue gas from a specially controlled boiler, or mixture of carbon dioxide and nitrogen from a gas producer. The correct use of such a gas removes fire or explosion risks; (3) solvent evaporated is recovered by "dead" gas circulating as follows: Impregnator—condenser—blower—scrubbers—impregnator; (4) pressure in impregnator is atmospheric, or just sufficiently above atmospheric to prevent leakage of air inwards, *e.g.*, 1/100 in. water. The properties of the condenser and cooler have been very carefully studied, but the mechanical details could be much improved by the prevention of creasing, the reduction of cleaning time, the maintenance of constant tension, the improvement of means for removing surplus solution, and the prevention of thick rubber on the material. There is only one such installation in this country. The gas is produced by means of an ordinary locomotive type boiler with mechanical stoker with means for carefully controlling air supply. The gas must be cleaned and chemically corrected before passing into the chamber.

Impregnating and Drying Chamber.—This consists essentially of a sheet-iron chamber containing two dip baths, rollers for running the cloth through and steam radiators for drying out the solvent. Alternate rollers are driven outside by chains. At least two speeds should be provided—a normal running speed and a slow speed. A reel-off for the cloth is fixed outside at one end, and a take-up for the impregnated material at the other end. One of the main difficulties is to regulate the stretch of the material in passing through the machine, consequently some form of constant tension take-up is essential. Another difficulty is to keep creases out of the material. No satisfactory means of doing this have yet been found, owing to the sticky nature of the cloth after impregnation.

Recovery Units.—These comprise a condenser and scrubbing plant. The condenser must be of ample capacity to keep the gas velocity low, in order to prevent condensed solvent being carried along mechanically in form of drops or spray. Manufacturers often supply condensers based on steam practice, which are quite inadequate. About 80 per cent. of the solvent should be recovered in this condenser. The gas and uncondensed vapour then pass to some form of scrubbing plant. A scrubbing oil is used. The Bregeat process uses cresol. A recent invention by W. K. Lewis uses a compression-condensation system of recovery, which should appeal to waterproofed cloth manufacturers.

Spreading.—This is largely carried out on tyre work, waterproof garments, aeroplane fabric, and proofed materials of all descriptions.

Spreaders.—The type of spreader generally in use has not changed during the last twenty years, and a cruder machine could scarcely be imagined. The types are: (1) Ordinary flat-topped machine with cast-iron or mild steel heating plates; both single-ended and double-ended. (2) Double-ended machines erected in the form of an inverted "V," which takes up less floor space. This is essentially the same as the ordinary flat-top machine. (3) Drum-spreaders, where steam-heated drums take the place of flat plates. (4) A new type of machine recently introduced by Olier, Clermont Ferrand, for spreading weftless cord direct from bobbins; this is of the drum type. The tendency in the United States for some purposes is to spread cloth in a machine similar to an impregnating machine, which enables the solvent to be recovered.

The main improvements of the ordinary types of spreading machine have been made at the instigation of the users, and not by the makers, and consist of such details as friction take-ups, hand brakes, &c. The steam consumption in spreaders using mild steel heating plates varies from 0·54 lb. to 0·75 lb. of steam per hour per square foot of plate area. Assuming the shop temperature to be 72 deg. to 80 deg. F., and steam pressure 5 lb. to 7 lb., it follows that waste steam from vulcanising presses can be used for this purpose.

Solvent Recovery from Spreaders.—A considerable number of attempts have been made during the last decade to recover the solvent evaporated from spreaders, but none can be regarded as final. The following are typical forms of apparatus for this purpose:—

The Bensin Condensation Actiebolaget, Malmo, Sweden.—A cover over the top of the spreader and a water-cooled basin underneath, which act as condenser. Recovery from this apparatus is said to be 60 per cent.

Voliq Apparatus, in which the heating plates are covered in, and a continuous current of air is circulated under the cover and through a condenser and reheater, only the top being covered in. About 60 per cent. of the solvent is recoverable.

Lewis Apparatus.—A covered-in machine with flue gas circulating under the cover and through a condenser and scrubber. This is the most efficient apparatus for recovery, which is said to be about 95 per cent. to 97 per cent.

Betaille System.—Is similar to the Voliq, but in this case a series of machines is connected to one condensing system.

The chief difficulty in recovering solvent from spreaders is the very low concentration of the vapour, and from this point of view an absorption process with charcoal or silica, treating either air drawn direct from these machines, or from the general atmosphere of the shop, should have distinct advantages. A recovery of about 90 per cent. of the solvent from very low concentration should be quite practicable. The disadvantages of almost all the types proposed up to the present are serious: (1) The machines use air and are liable to fire; (2) coverings prevent accessibility to cloth; (3) a number of small recovery units is not desirable; (4) it is advisable to carry on the recovery outside the spreading room, if possible; (5) Any system relying on cooling alone must of necessity give low returns. Air at 80 deg. F. will hold 13·5 per cent. by volume of benzol. This will not condense unless a lower temperature can be obtained, and this requires a large cooling apparatus. (6) In order to keep the concentration of solvent vapour as high as possible, air leaks must be eliminated and the air used passed as slowly as possible through the machine. This slows up the drying operation and therefore reduces output.

Calendering.—Frictioning and skim coating rubber on canvas or fabric requires the material to be dry and warm, a steam-heated drum being used for this purpose. The latest machine is the cell drier, a very efficient plant

composed of steam-heated chests, a useful addition here being the Foxwell guide to ensure square batching on the box roller. Frictioning consists of passing the cotton material through a three-bowl calender, the centre bowl of which is travelling faster than the top or bottom. Rubber is fed in between top and middle bowls, the different speed of the rolls forcing the rubber through the cotton material. Few improvements are noted in the design and operation of the calender, advances being chiefly in size of machine. The size used is up to 90 in. in width, with variable speed from 1 yard up to 60 yards per minute. The elevating and lowering of the top and bottom rolls to control the gauge of rubber and finished material, is operated on the latest types of calender by small subsidiary motors, controlled by the calender man, an operation which was previously done laboriously by hand. Cutting pieces out and testing with a micrometer gauge is the usual practice. What is required is a gauge accurate to $\frac{1}{100}$ mm., indicating during the actual calendering operation. Several types of gauges for measuring thickness of material are manufactured, but none is sufficiently accurate to be of real use. Frictioning and topping calenders need a cooling device for the treated cloth before batching up in the lining to avoid possible sticking, air cooling being generally used. Fitting a stand at a distance from the calender for cooling the canvas better has only been partly successful. Much improved batching gear is necessary on modern calenders. No satisfactory cloth tensioning device to act automatically is yet obtainable; most machines are provided with ordinary hand-operated band brakes, and the manufacturer is left to depend on the skill of calender operators.

Topping calenders differ from frictioning calenders in that all three rolls are driven at the same speed, and topping is usually a separate operation (see Figs. 24, 25 and 26). In America attempts have been made with some success to friction and top the materials in series. This, however, must be full of complication, and from the point of view of scrap, &c., it is probably profitable to split the operation. It is essential that the rubbered material should be run over a viewing machine in order to examine and to loosen the lining from the rubbered material to expedite the subsequent processes, in which the material will be cut as required. Rubber calenders need definite roll location and temperature control and should have roller bearings.

Extruding or Forcing Machines.—These machines are used to force certain rubber compounds through dies, in order to obtain exact profile shapes. The extruded rubber is uncured, but must be worked to very definite limits. Extruding machines are used for manufacturing light and heavy tubes for various purposes, laying on layers of rubber to cables, belts, &c., and extruding strip and block from light and thin sections to heavy and square sections of any desired profile. There is much to be discovered by engineers as to what governs the correct extrusion of rubber. The chief difficulty in all rubber work is to keep the conditions constant. All water supplied to the cylinder and screw, should be controlled, and suitable means supplied for observing temperature. The die should be steam-heated or preferably electrically heated, and a thermometer pocket provided in the die. The screw must be efficiently cooled. The screw is of heavy dimensions, and means must be provided for taking the thrust; the Michell thrust bearing has given much satisfaction.

Extruding machines in use range from 2 in. diameter up to 16 in. diameter, and require from 10 h.p. to 120 h.p. The horse-power required for extrusion of rubber varies with the rubber stock (see Fig. 28), amount of mastication, degree of warming, form and speed of screw, ratio of die area to cross-section of cylinder. On the smaller diameter extruding machines a constant speed can be used, but on larger machines it is advisable to employ a variable-speed motor, and if the supply is alternating current, a three-phase commutator motor will be found well suited. The best form of screw for a uniform product is a two or three start screw. With heavy output machines, the single start screw is most efficient, and provided the volume of the die-box is kept low, and the rubber stock is not of too low gravity, good results are possible. Dead rubber in the die-box goes very much against successful extrusion. By experiment it has been shown that when extruding rubber of a white mix, followed by coloured mixes such as brown, yellow, black, red and blue, the die-box after a period of 6 hours is lined with the first colour, the colours arranging themselves in sequence. It has been noted that the first colour completely coated the black material to the extent of $\frac{1}{1,000}$ in., uniformly as though by design. This points to the fact that the rubber flows chiefly through the centre of the die-box, but holds on to the die-box walls, where its velocity is practically zero. Trouble may thus be experienced through the rubber becoming semi-cured in the die-box. The density of extruded stock varies considerably because of this uneven flow.

The machine "take away" is an important item. The extruded shape can be altered at will by the stock packing back on the die, and so thickening up, or by drawing away and thinning down. This variation can be obtained by gravity rollers, by trough, or by means of mechanically-driven variable-speed conveyor belts. The effect of rubber in the die-box is similar to a spring underload, and it is obvious that the feed is in nature intermittent into the screw at the feeding point. Periodic pulsations may be set up, and this is often shown on the extruded article. The temperature of extruded rubber is about 80 deg. C. At this temperature the rubber is very easily stretched or distorted, so that if it is extruded to exact limits it is necessary to cool it so that the section shape does not change, and so that the shrinkage will be on definite lines, giving a uniform result at the finish. To obtain this result, strip stock is often cooled by arranging to give the "take away" belt a long travel. Other schemes take it through a water trough, or run a copper gauze close woven belt which is water-cooled on its return travel. This is found sufficient to cool the rubber, but the common method is to batch the strip into linings on drums, and air cool, and it is then necessary to equip a definite "take-off" gear which will feed the drums with constant speed and tension.

Tubes are extruded through a special die with a centre, and it is obvious that the rubber will stick together on the inside unless special precautions are taken. An opening is provided for powdered chalk, which passes through the die-box to the centre of the tubing being extruded, and so coats it with chalk, preventing sticking. The tubing, owing to its nature, is very active; so far only air cooling has been adopted, and, if the tube could be set for cutting to length, far better control of the product would be secured. Cooling heavy extruded sections is even more vital, and special conveying plant must be devised, to enable the extruded stock to be tipped into an automatic conveyor, which, in some cases, travels a distance of 60 ft. under water, the stock being automatically tipped on to a cutting table after rising above the surface. If some means could be devised for cooling the stock immediately it leaves the die, a big advance on present-day methods would be the result. The speed of extrusion, and the slow rate that rubber gives up heat, are factors that make the problem difficult. Hydraulically extruding stock has been experimentally attempted, but the lack of continuous flow has not allowed its adoption. Forcing machines sweep up only 30 per cent. of the screw volume in rubber and so include much air.

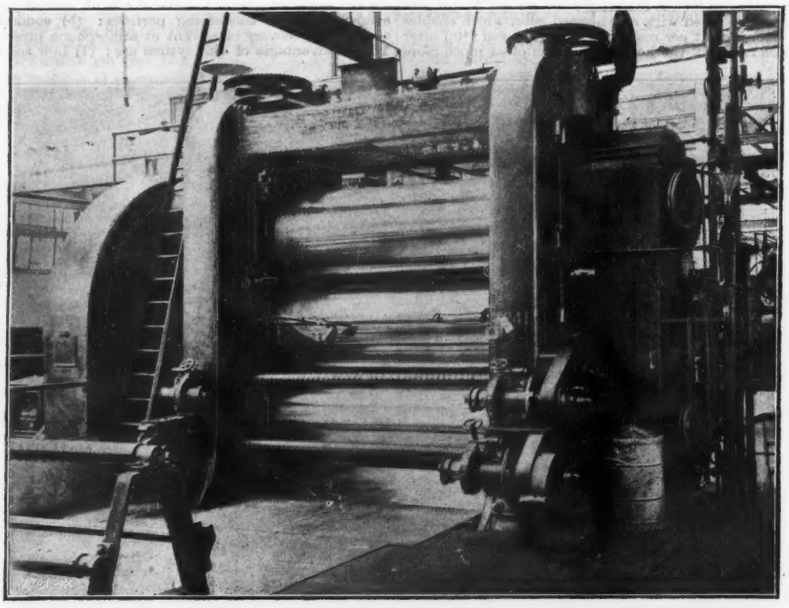


FIG. 25. 90-IN. CALENDER, SHOWING CANVAS FEEDING GEAR AND WATER AND STEAM SUPPLY TO ROLLS.

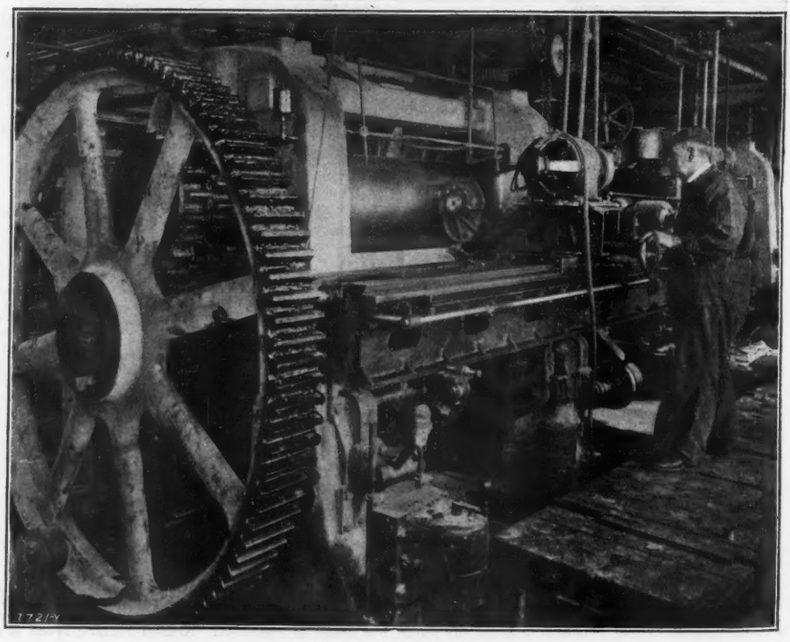


FIG. 26. GRINDING CALENDER ROLLS.

Vulcanisation Plant.—There are three main types of vulcanisation plant, namely, open cure plant, open-pan cure, and hydraulic pan cure.

Open Cure.—In this the vulcanising heat is obtained from hot plates, and the necessary pressure on the moulds provided by bolts or hydraulic pressure. The ventilation in and around the presses must be such as not to affect the work and produce difference of temperatures. Bad work is often produced on this class of plant by windows or doors adjacent to the presses being opened, most of the cures in this type of press being in the nature of 2 minutes to 6 minutes, and subjected to the temperature of steam at pressures from 20 lb. to 60 lb. per square

SOME MECHANICAL PROBLEMS IN THE RUBBER INDUSTRY.

Fig. 27. CHART SHOWING TYPICAL LOAD ON 48 INCH WARMING LINE DRIVEN BY 250 B.H.P. MOTOR.

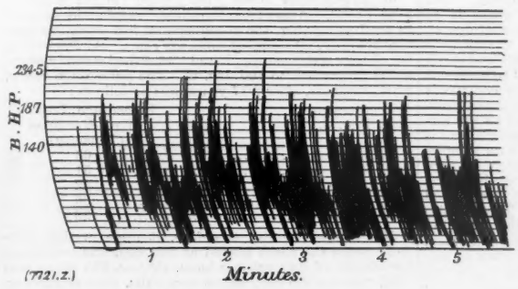
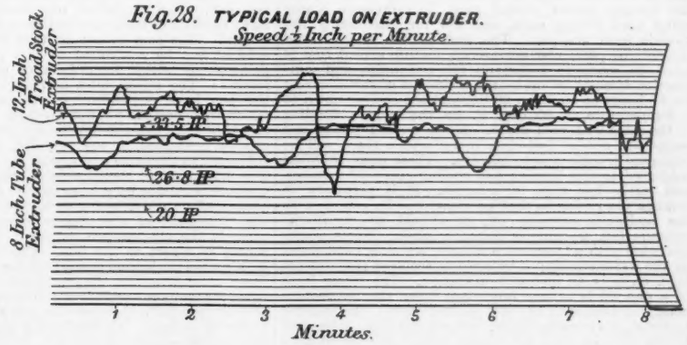


Fig. 28. TYPICAL LOAD ON EXTRUDER.
Speed ¼ Inch per Minute.



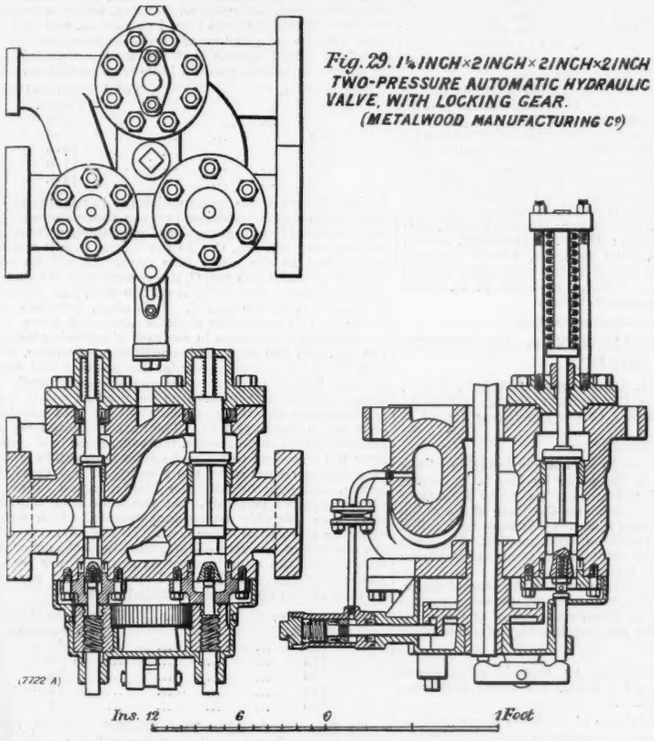


Fig. 29. 1⅛ INCH × 2 INCH × 2 INCH × 2 INCH TWO-PRESSURE AUTOMATIC HYDRAULIC VALVE, WITH LOCKING GEAR. (METALWOOD MANUFACTURING Co)

Fig. 30. CONTROL OF EXPANSION BY HYDRAULIC PRESSURE.

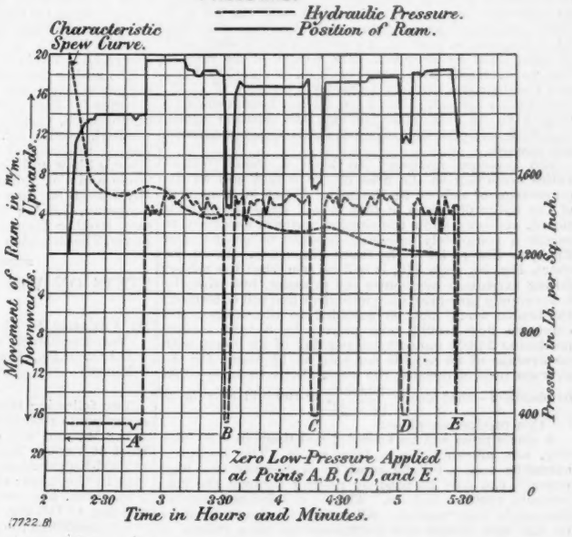
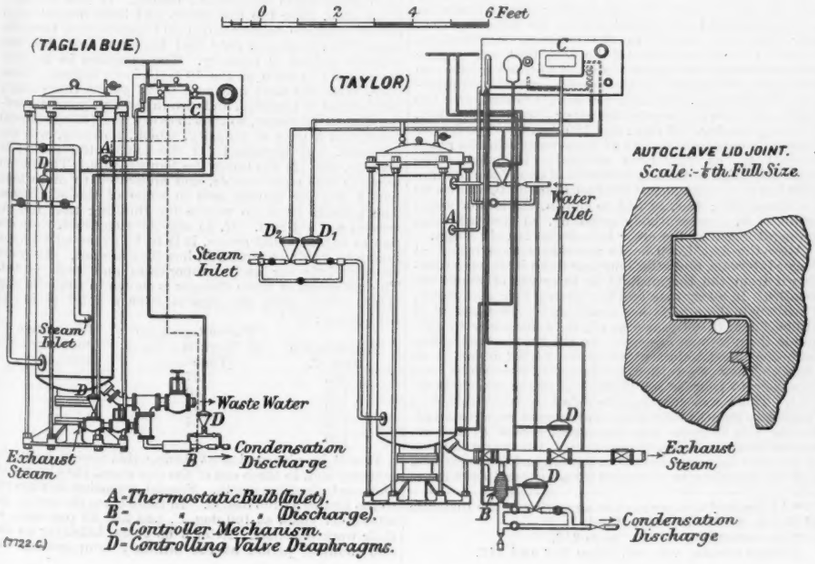


Fig. 31. TEMPERATURE CONTROLLERS



AUTOCLAVE LID JOINT.
Scale:- ¼th Full Size.

inch. Effective insulation of all parts must be taken in hand, and as few convection currents as possible allowed, which must have a definite direction to create sufficient cooling and a feeling of comfort to the workers.

Open-Pan Cure.—In this the articles are placed in a steam pan in bolted moulds, or wrapped in position on half-moulds or mandrels. These pans vary in size, 36 in. by 36 in. to 30 ft. by 6 ft., and in the case of large diameter pans 10 ft. by 20 ft. Most open curing pans are horizontal, but the nature of the product settles this as, in the case of very heavy wheel material, they must be vertical. Goods cured on carriages can be placed in pans set horizontally. The draining of the pan, the inlet and outlet of the steam, the door fastening and joints, are points requiring minute attention. In all steam-curing pans, whether of the open curing or autoclave type, an even temperature must be sustained and excess-heat pockets and air pockets eliminated. If drenching or flooding is necessary the water must be drained away quickly and effectively, and a dry pan be ready for the next cure. By arrangement of the inlet pipes and the vent pipe, an even temperature can be obtained. As sulphur is the chief curing ingredient and is used in as high a percentage as 20 per cent., the piping and valves are attacked and a high renewal bill has to be faced unless care is exercised in the placing of valves. Process steam from a vulcaniser using high sulphur mix, cannot be returned to low-pressure heating main.

Pan doors till recently were of the bolted type, necessitating lifting tackle or runways to take the door to right or left of pan. This in either case was a hindrance to production, and very serious accidents have occurred by workers releasing bolts with pressure in the pan, either because the gauge indicated zero when 4 lb. or 5 lb. were still present, or the eagerness of workers to open the pan, making them reckless of danger. Present-day practice is to hinge the pan-door and use a bayonet joint. This eliminates the operation of lifting or trolleying the door, reduces the time of opening and closing of the pan to a minimum, and is a safeguard against premature opening of the door, because with the pressure in the pan as low as 1 lb., opening the pan door on a bayonet joint requires extra work, and warns the worker of danger, should steam be present from an unusual cause. The type of door joint should be of the lip type, and possible damage of the joint will be much reduced. The chief precaution with the horizontal bayonet joint is to see

that the hinge is of steel, robust in design and well balanced.

Hydraulic Curing Pan or Autoclave.—Here the steam pan is supplied with a hydraulic press, which keeps the moulds closed during cure, high-pressure water being used during cure, and low for discharging the moulds from the pan. The shell of the steam vessel presents no particular engineering feature except that it must be made to withstand the expansion and contraction stresses set up by the operation of steam curing for 1¼ hours at 40 lb. to 60 lb., and the cooling down to a temperature of 80 deg. F. by the sudden flooding of the pans with cold water. If the riveted joints and seams are not of first-class manufacture there will be continual trouble due to leakage. These pans are often subjected to this heating and cooling every 30 minutes, and rarely less than 90 minutes. It is necessary to arrange the piping so that no steam can be put on with the hydraulic pressure off, or should the hydraulic pressure fail, warning is instantly given. Some plants are fitted with a locomotive whistle, which is kept closed by the water circuit; if by error or accident the pressure fails, there is an instant notification. The steam joint of a pan lid is a very important item, the lip pattern being the best with bayonet-jointed doors; the jointing material, if correctly made, will require little attention. If the material does not remain flexible it fails to close the joint on the rise of a cure, and the noise created can be heard in still air as far as 2 miles to 3 miles from the factory. With a moulding shop of 20 or 30 pans it would be impossible to work with the joints giving this trouble. As autoclaves are nearly all vertical, and the lid of a 54-in. pan weighs about 2 tons, it is clear that when the lid is dropped in position, to rotate it easily some sort of roller must be provided. The weight of the door is able to overcome a pressure of 1 lb. per square inch, and the door can actually be under a pressure of 1¼ lb. and still be opened. The 2-ton lid has been known to blow 3 ft. to 4 ft. clear, falling into position again, repeating this performance until the emergency exhaust was opened.

The pressure necessary to keep a mould closed varies according to the area of the mould and to the percentage of rubber in the mix. What is demanded of the hydraulic press is that it will keep the moulds closed, and only allow the surplus material necessary to ensure a completely moulded product to escape, and the spew line to be of the finest dimension. From the chart, Fig. 30, page 315, it will be seen that the rubber during expansion overcomes the pressure, but with the lower supply pressure a very wide spew line will be formed; the article would not be moulded to dimensions, and excessive flow would take place. In a tyre factory producing 25,000 motor tyres per day of 20 hours, with an average of 25 moulds per pan, at 1¼ hours, for the average time of opening the pans, about 10 cures could be obtained—that means $\frac{25{,}000}{10 \times 25}$, or 100 odd autoclaves for this production alone.

A single press will be operated 600 times in a 20-hour day, not allowing for a false move. The hydraulic operating valves, Fig. 29, must be so designed that high pressure can only be used by passing through the low-pressure position full on. This is a safeguard against the supply being wasted. All joints and glands must be of the best design and workmanship, as a failure of pressure during cure can easily mean a loss of anything up to 300*l.* per pan. It will be noticed that when unloading a full pan, if creeping of the ram takes place, or any failure of the operating valve occurs, the pile of moulds can be pushed into the roof beams or through the ceiling in a multifloor building. A safety device must therefore be installed either to operate the individual press or to cut off the pressure supply.

This final and very important operation of vulcanisation is governed by three factors: (1) Curing ingredients in the mix; (2) length of cure; and (3) temperature of cure.

Except for the correct mechanical mixing, item (1) is controlled by the chemist. Time of cure, and temperature, were until quite recently controlled by clock and steam gauge. Temperature recording instruments are now easily obtained as distinct from steam pressure recorders, but the Tagliabue and Taylor type of control are successful attempts at controlling temperature and length of cure automatically and independently of the human element. Attempts have recently been made to cure with low-pressure superheated steam, but it is not possible to maintain a uniform temperature through the pan, so that no practical results have been obtained. The advantage would be a lighter type of plant all round. Vulcanisation can be obtained by oil, metal and hot water baths, and for some purposes by electrically-heated moulds.

Vulcanisation with External and Internal Pressure.—Patents have been taken out which provide special steam-jacketed moulds capable of taking a range of sizes and patterns, which can be securely bolted together and the internal pressure applied, the resistance of the bolts acting for the hydraulic press in this method of vulcanisation. This new method of curing would indicate very distinct advantages as far as reduction in necessary capital, operating charges, easy inspection, and handling are concerned. Two methods are in vogue for filling the moulds with gas for internal pressure; one is to make the connection out of the pan and inflate to final pressure, and the other is to have a series system of connections, and inflate after the pan lid is closed maintaining the pressure from a main.

Automatic Temperature Controls (Fig. 31).—This system is worked or controlled by the temperature of the steam in the pan. The device consists of a thermo-pot, which contains two thermostatic bulbs and carries a thermometer. These bulbs are filled with ether, one bulb being connected by armoured capillary tube to the temperature recorder, and the other to the automatic temperature control instrument. The temperature recorder is of the standard type, and works on the Bourdon pressure gauge principle, and has suitable clock mechanism and pen. The Tagliabue temperature control instrument consists of suitable clock mechanism which carries a cam. This cam is cut so that the steam inlet and exhaust can be controlled to suit requirements. The principle on which the Tagliabue control works is as follows: The steam inlet and exhaust connections to the pan have controlling valves carrying diaphragms which are operated by compressed air. The bulb and capillary tube from the thermo-pot are connected to a vapour capsule contained in the recorder, and this capsule is subjected to the same pressure as the vapour in the bulb. The movement of the capsule is transmitted to the air-pressure regulator by a lever carried on trunnions, and is controlled by a regulating cam. Thus the cam governs the movement of the vapour capsule, which in turn controls the air-pressure regulator which regulates the supply of steam to the pan. The exhaust is operated by a special projection carried on the cam. There is also fitted a condensation discharge valve and thermo-bulb; when the temperature falls due to condensation in the pan, this thermo-bulb operates the valve and allows all the water to escape. In the Taylor system there are two inlet valves—direct action D1, and reverse action D2; the latter valve is only to preclude the possibility of valve D1 being opened under conditions such as water in the pan when flooding, which, due to thermal conditions in condenser, would open valve D1. This extra valve is fitted for pans flooding after cure.

A chart showing the load on a typical warming line is given in Fig. 27. A comparison of typical warming mills was given in Table IV, page 281, *ante*.

The author desires to acknowledge his indebtedness to numerous firms and individuals in Great Britain and America for kindly supplying information, drawings and photographs, particularly Messrs. Henry Berry and Co., Limited, Leeds; Mr. James Nuttall, Castleton; Messrs. David Bridge and Co., Limited, Castleton; Messrs, Francis Shaw and Co., Manchester; Messrs. Fauset, Gillespie and Co., Edinburgh; Mr. P. G. Bradford, Leeds; Mr. David R. Bowen, chief engineer, Farrel Foundry Company, U.S.A.; Mr. Bryan T. Mottinger, The Quaker City Rubber Company, U.S.A.; and Mr. J. R. Gammeter, The Goodrich Company, U.S.A.

TESTS ON WORK-HARDENED ALUMINIUM SHEET.*

By Professor H. C. H. CARPENTER, A.R.S.M., F.R.S. (Past-President), and C. COLDRON SMITH, A.R.S.M., D.I.C., M.Sc., Member. (From the Royal School of Mines.)

INTRODUCTION.

THE following tests are in part a continuation of the experiments recorded in the paper by Mr. L. Taverner, A.R.S.M., and one of the authors on "The Effects of Heat at Various Temperatures on the Rate of Softening of Cold-Rolled Aluminium Sheet."† It may be recalled that in this paper the authors experimented with sheet ⅛ in. thick, and carried out tests at temperatures from 550 deg. to 100 deg. C., inclusive.

In considering the results recorded in the present paper, it will probably be found convenient to refer to one published by Miss C. F. Elam and one of the authors entitled "Stages in the Recrystallisation of Aluminium Sheet on Heating."‡

LONG-PERIOD EXPERIMENTS AT THE TEMPERATURES 200 DEG., 175 DEG., 150 DEG., 125 DEG., 100 DEG., 75 DEG. AND 50 DEG. C.

The test-pieces, which were of the same shape as those recorded in the first-named paper, have been heated under the same conditions, i.e., they were contained in thermostats maintained at the seven temperatures mentioned. Two test-pieces were withdrawn after stated intervals, and mechanical tests carried out on the following day, after they had cooled to the ordinary temperature. Attention is drawn here to the fact that two of the temperatures are not quite the same as those referred to in the previous paper. In the present series the temperatures are 200 deg., 175 deg., 150 deg., 125 deg. and 100 deg. C., whereas in the previous paper they were 200 deg., 170 deg., 155 deg. 125 deg., and 100 deg. C. The former represents equal differences of temperature in the range referred to, as had been originally intended. The slight alteration in the temperatures of two of the thermostats has as a consequence the fact that the two series do not fit exactly; but, as will be shown, the loss of work-hardness is, comparatively speaking, so slow at these temperatures that the error introduced is only slight.

After the first 1,560 hours the sheets were tested at longer intervals, and after one year test-pieces were withdrawn from the thermostats at intervals of about six months. In every case two test-pieces were withdrawn.

Although these tests have extended over a period of 41,000 hours (4·68 years) in all, it is necessary to subdivide them into two groups. In the first instance, they were continued uninterruptedly for 21,592 hours (2·46 years). They were then interrupted, because it was necessary to transfer the thermostats to another laboratory. There was considerable delay in doing this, and it was two months before the experiments were restarted. During this interval the test-pieces cooled to and remained at the ordinary temperature. On the resumption of the tests they were heated to the original temperatures, and the experiments continued for a further 19,408 hours (2·22 years). As will be subsequently seen, this interruption with the consequent cooling of the specimens to the ordinary temperature, followed by their reheating, had a most important influence on the rate of softening of the test-pieces. The total period of 41,000 hours has therefore to be subdivided into two periods of 21,592 hours and 19,408 hours respectively.

(*a*) *Experiments in the First Period* (21,592 *Hours* = 2·46 *Years*).—Apart from the slight irregularities referred to on first heating, the specimens all lost work-hardness continuously, although at different rates. At 200 deg. C. the change was most rapid, and diminished steadily as the series progressed to 100 deg. C. The percentage loss of work-hardness, after 2·17 years, was as follows:—

Temperature, Deg. C.	Percentage Loss of Work-Hardness (Tenacity).
200	66
175	51
150	42
125	36
100	23

From these figures, therefore, it appears that after 2·17 years the sheet heated at 200 deg. has lost about two-thirds of its work-hardness, that at 175 deg. about half, that at 150 deg. about two-fifths, that at 125 deg. about one-third, and that at 100 deg. about a quarter. Had the experiments not been interrupted, and had the same average rate of loss of work-hardness been maintained, it would appear that the total estimated time for complete softening would have been as follows:—

Temperature, Deg. C.	Total Estimated Time (Years).
200	5·0
175	7·0
150	10·0
125	11·0
100	14·5

Against these periods, upon which too much stress must not be laid, since they depend on the above assumptions, may be placed the times required for complete softening at 250 deg. and 300 deg. C. In the former case it was five weeks, and in the latter four days. It will be seen, therefore, that at 200 deg. C. the average rate of softening is only about $\frac{1}{7}$ of what it is at 250 deg., and about $\frac{1}{21}$ of what it is at 300 deg. C. It is clear, therefore, that as far as this particular sheet is concerned there is an extraordinary difference in the rate of softening between 250 deg. and 200 deg. This conclusion, of course, holds only for sheet of this particular composition and degree of work-hardness. The paper contains not merely the figures of tenacity representing the gradual loss of work-hardness, but also the mean elongation figures calculated on a gauge length of 3 in. The authors do not lay any great stress on these results, however, since it is evident from the fractured test-pieces that a perceptible amount of shearing occurs after the slipping of the metal has begun, and consequently the broken pieces cannot be pieced together perfectly. At the same time duplicate tests give tolerably concordant results, which seldom differ by more than 4 per cent. In the following table the percentage recovery of elongation has been calculated, based upon the experimental figures of 7 per cent. in the case of the work-hardened sheet, and 42 per cent. in that of the completely softened sheet:—

Temperature, Deg. C.	Percentage Recovery of Elongation
200	43
175	23
150	24
125	16
100	8

(*b*) *Experiments after Two Months' Interval, during which the Specimens remained at the Ordinary Temperature* (*Total Period*, 19,408 *Hours* = 2·22 *Years*).—These tests have given some unexpected results. It was found in every case, after the test-pieces had been heated up to the appropriate temperatures and maintained there for some time, that not only had they not lost, but had actually gained in tenacity. The increases in tenacity were found in each of the 10 test-pieces tested. Moreover, after the next half-year (3·23 years) there was a further rise in tenacity, and also in the half-year succeeding that (3·65 years), so that in every case (30 specimens) there was a gain of tenacity, which, however, was not constant, but increased (1) the longer the period of heating, and (2) the lower the temperature. The rise in tenacity was considerable, and amounted to more than half a ton per square inch in some of the specimens. The authors have no reason for thinking that the increases are not real. If, as may be suggested, they are due to experimental errors, it is to be expected that the increases would be constant, but they are not. They are characteristic for each temperature and each period. The net result of these changes is shown in the following table, which gives the figures after a total period of 3·65 years:—

Temperature, Deg. C.	Percentage Loss of Work-Hardness (Tenacity).	Percentage Recovery of Elongation.
200	57	51
175	40	25
150	30	22
125	24	12
100	11	13

It will be observed that during this period both the tenacity and, in three out of the five cases, the elongation increased simultaneously. Special attention is directed to the figures at 100 deg. C. In these cases the specimens after 2·17 years at 100 deg. C. had lost 23 per cent. of their work-hardness. After 3·65 years, following on the two months' period at the ordinary temperature, the

* Abstract of a paper read at a meeting of the Institute of Metals, on Wednesday, March 7.

† ENGINEERING, vol. civ page 312.

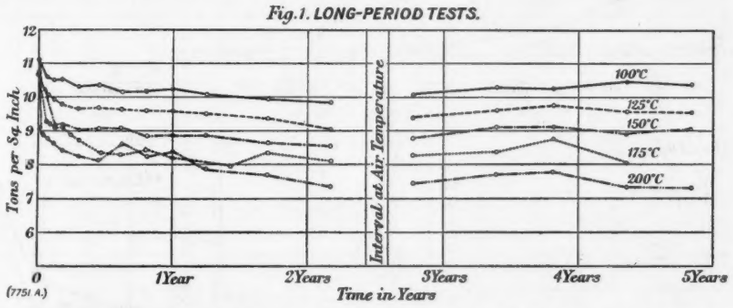
‡ ENGINEERING, vol. cxi, pages 302 and 316.

percentage loss of work-hardness was rather less than half this, viz., 11 per cent.

After the next interval, however, (4·19 years) it was found that in four out of five cases the increase in tenacity was no longer observable, but had been succeeded by a decrease. In the case of the specimens heated at 200 deg. and 175 deg. C., the figures are almost identical with those observed after 2·17 years. The drop in tenacity, although noticeable, was less marked at 150 deg. and 125 deg. The specimens tested after 4·19 years, at 100 deg., however, showed no decrease in tenacity, and the figures obtained were identical with those after the preceding period (3·65 years). In the period 4·68 years, the figures obtained hardly differ appreciably from those of the preceding period. The net result was, that after 4·68 years the percentage loss of work-hardness in the specimens heated at 200 deg. was the same as after 2·17 years, and that in the specimens heated at 150 deg., 125 deg. and 100 deg. C. it was less after 4·68 years than after 2·17 years.

A possible explanation of the rise in tenacity extending over a period of more than one year in the specimens which, after being heated for 2·17 years, were cooled to the ordinary temperature, maintained there for two months and then reheated to the corresponding temperatures for further periods, has been sought but not found by the authors. This matter is more fully referred to further on. There can be little doubt that this two months' interval had a disturbing effect on the conditions of the specimens, and therefore it does not appear admissible to consider their behaviour at the temperatures in question, as though this interruption had not taken place. From the point of view of judging the question, whether, provided the specimens were heated uninterruptedly at the temperatures 200 deg., 175 deg., 150 deg., 125 deg. and 100 deg. for a sufficient time, they would ultimately completely soften, as they undoubtedly did in the range from 250 deg. upwards, the data obtained by the authors cannot be utilised after the period of 2·17 years. This is unfortunate, because it is less than half the total period of the test. The total time estimated for complete softening at the five temperatures in question, on the assumption that the rate of loss of work-hardness remains constant for each temperature, varies from about five years at 200 deg. to nearly fifteen years at 100 deg. C. In the authors' view, provided complete softening does take place, the periods are likely to be, if anything, rather longer than those estimated. Though the answer to the main question cannot yet be given, it does appear as if the retention of work-hardness in the case of aluminium of the composition tested (copper 0·03 per cent., silicon 0·35 per cent., iron 0·7 per cent. to 0·8 per cent.) was sufficiently marked in the temperature range 200 deg. to 100 deg. C. to enable practical advantage to be taken of this property.

Fig. 1. LONG-PERIOD TESTS.



The microscopical examination of the sheet tested in the long-period tests from 200 deg. to 100 deg. C. was made on specimens cut from the broad ends of the test-pieces. So far as the authors have been able to observe, evidences of structural changes are very slight, even after a total period of 4·68 years. Certain indications of recrystallisation are confined to the surface of the sheet. The chief structural change consists of a general tarnishing produced by etching, the development of a granular structure, and the blurring of the original boundaries of the flattened crystals, characteristic of the work-hardened metal. As shown in the second paper above referred to, the structure of the sheet is that of a metal in which the crystals have been rolled into one another and to some extent divided. The crystal boundaries are so close together as to give the appearance merely of a number of parallel lines running in the direction of rolling. Close inspection shows that occasionally two of them converge and meet, indicating that they are genuine crystal boundaries. This characteristic appearance is still maintained to a very large extent in the sheet heated throughout the prolonged period of the tests. It would not be correct to say that there is no recrystallisation at all in the sheet. There are, undoubtedly, evidences of this on the surface, but they appear to be confined to it. If there were any substantial development of new crystals, it would be justifiable to conclude that the loss of work-hardness observed in the sheet would have been greater.

After it had become obvious that the softening of the sheet in the range 200 deg. to 100 deg. C., though very slow, was nevertheless quite marked, it was decided to institute similar experiments at two lower temperatures, viz., 75 deg. and 50 deg. C. These were carried out under conditions precisely similar to those of the preceding series, both as regards methods of heating and of testing. The total period of the tests was 4·14 years. As regards those carried out at 75 deg. C., the losses in tenacity observed were very slight, and in one case only amounted to as much as 0·27 of a ton. For the most part, the variations from the figures characteristic of the original sheet come within the experimental errors of the method, especially having regard to the fact that impurities are distributed not quite uniformly throughout the sheet. At 50 deg. C. the losses observed were even less. In both sets a number of values were obtained, indicating a tenacity higher than that of the original sheet, and these were particularly marked in the tests carried out at 50 deg. C. No emphasis, however, is laid on these, as it is doubtful whether they cannot all be brought within the experimental variations of the tests. One conclusion can certainly be drawn, and that is, that from the practical point of view the retention of work-hardness at the temperatures 75 deg. and 50 deg. is complete, at any rate up to a period of four years. There is rather a decided tendency to increase in tenacity in the period from 2·17 to 4·19 years. This is the period following the interruption of the tests for two months. The increase, however, is manifest at an earlier period in these two cases, because the tests were started nearly six months later, and therefore the interruption occurred at a correspondingly earlier period.

The results of the long-period tests from 200 deg. to 50 deg. C. are given in Fig. 1, which has necessarily to be drawn on a very restricted time co-ordinate. Consequently, the fluctuations in tenacity shown in the first 100 hours are not rendered visible. Fig. 1 enables the fluctuations in tenacity of the five sheets to be studied over the total period of the tests, with the limitation just referred to. The gain in tenacity of the various sheets, consequent upon the interruption of the tests and the two months' interval at the ordinary temperatures, is clearly seen in the figure.

The gradual rise in tenacity exhibited by the sheet after the two months' interval at the ordinary temperature, followed by reheating, is certainly, at first sight, a somewhat surprising result. Any attempt to explain it requires a knowledge of the constitution of the alloy in question under equilibrium conditions, together with the effect of temperature variations throughout the range experimented on, and, in addition, a knowledge of the influence of cold-work upon these. Complete information on these points does not exist at the present time. On pages 211 to 216 of the "Eleventh Report to the Alloys Research Committee of the Institution of Mechanical Engineers," by Rosenhain, Archbutt and Hanson, will be found valuable information with regard to the physico-chemical constitution of the iron, silicon, aluminium alloys. Dr. Hanson has supplied the authors with further information, for which they are greatly indebted.

The sheet with which they have been experimenting contains copper 0·03 per cent., silicon 0·35 per cent., iron 0·8 per cent. (mean figures). The amount of copper present is very small, and in order to avoid complications can probably be neglected without serious error. It appears from a consideration of Fig. 121 of the "Eleventh Report to the Alloys Research Committee" that the course of freezing and cooling of such an alloy is somewhat as follows: The first separation from the liquid consists of an aluminium-rich solid solution. At a slightly lower temperature an aluminium-iron binary complex separates. At a rather lower temperature this complex, which consists of the compound $FeAl_3$, reacts with a portion of the liquid to form a new constituent, which is called X by the authors of the Eleventh Report. According to the diagram, Fig. 2, which the authors owe to Dr. Hanson, the constitution of the alloy in question just below the solidus is given at the point indicated. In explanation it may be stated that the full lines have been determined experimentally, while the dotted lines are theoretical. It appears from this that the alloy in question is definitely within Al + X field just below the solidus. Dr. Hanson writes: "We should expect an alloy containing 0·35 per cent. of silicon and 0·8 per cent. of iron to consist of X and the aluminium-rich solid solution and be free from silicon and $FeAl_3$ . . .

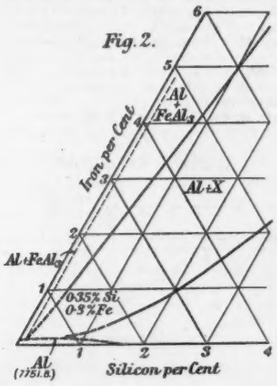
We do not know the composition of the constituent X, but we have certain evidence which suggests that it is a ternary constituent containing aluminium, iron, and silicon, and that the proportion of iron (by weight) that it contains is considerably greater than the proportion of silicon." Whether in cooling from 600 deg. to the ordinary temperature the alloy still remains in the Al + X area is not yet known.

In answer to the authors' question as to the solubility of X in aluminium, Dr. Hanson wrote: "The solubility of X in aluminium is very small at all temperatures. It is so small that we have not been able to determine it in that part of the diagram near the aluminium corner. I should not anticipate much variation in solubility between 0 deg. and 200 deg. C., though such variation probably exists." Dr. Hanson has also informed the authors, that he has no information on the effect of cold work on the solubility of X. It must be realised, therefore, that complete data are not available for predicting the behaviour of the alloy under the conditions obtaining during the author's tests. In the absence of such data it does not seem justifiable to speculate.

The authors have considered the matter from another standpoint, and have regarded the worked sheet as a complex of severely deformed crystals embedded in a vitreous matrix, such as is conceived to occur on the Beilby theory of cold-work. They have sought for an explanation of the phenomena observed on the basis of the variation in properties which such a complex might be expected to show under the conditions of the tests. Unfortunately, here also the data for forming a scientific opinion are not available. In their absence it seems wiser to refrain from what can only be speculation.

Tests at Air Temperatures.—Tests have also been carried out at various intervals at the ordinary temperatures. Test-pieces cut from the sheet $\frac{1}{4}$ in. thick were first tested on September 18, 1916. They gave the mean value of 10·83 tons per square inch ultimate stress. Thereafter samples cut from the same sheet were tested at intervals of one, three and five years. The specimens tested after one year gave a result identical with that of the original sheet. Those tested after three years showed a very slight fall (mean value, 10·77), but it is well within the variation liable to occur with duplicate test-pieces, and cannot therefore be considered to indicate any loss of work-hardness. After five years a fall in tenacity of 0·19 of a ton per square inch was found. This is perhaps larger than the experimental variation of the method, but, even so, is a comparatively small amount. It may be concluded, therefore, that at ordinary temperatures sheet of this particular degree of work-hardness tends to lose it only to an extremely slight degree, so slight, in fact, that it is scarcely appreciable. It may be noted that the percentage elongation obtained on fracture showed a slight tendency to fall with the lapse of time. So far as the authors' tests go, therefore, they indicate that not only at air temperatures, but up to 75 deg. C., the work-hardness conferred on the sheet is, practically speaking, remarkably stable.

Fig. 2.



The Influence of Thickness.—In these tests plates of three different thicknesses were tested, each at three different temperatures, so that there were nine sets of tests in all. The thicknesses of the plates were intended to be $\frac{1}{8}$ in., $\frac{3}{16}$ in. and $\frac{1}{4}$ in. In point of fact, the thickness of the last-named plate was $\frac{1}{12}$ of an in. In other words, it had had rather less work done upon it than was intended. The temperatures chosen were 500 deg., 250 deg. and 125 deg. C., corresponding to rates of softening, which may be described as very rapid, rapid and slow.

Plate.	Tenacity. Tons per Sq. In.
$\frac{1}{8}$ in. thick:	
Hardened	10·80
Softened at 500 deg. C.	5·76
Softened at 250 deg. C.	5·76
Work-hardness	5·04
$\frac{3}{16}$ in. thick:	
Hardened	11·07
Softened at 500 deg. C.	5·80
Softened at 250 deg. C.	5·71
Work-hardness ... ...(mean)	5·31
$\frac{1}{4}$ in. thick:	
Hardened	11·78
Softened at 500 deg. C.	5·85
Softened at 250 deg. C.	5·89
Work-hardness ... ...(mean)	5·91

The tenacities of the three sheets were, of course, different in the work-hardened condition, being least in the $\frac{1}{8}$-in. sheet and highest in the $\frac{1}{4}$-in. sheet, but after heat-treatment for various periods at 500 deg. and 250 deg. they were found to be almost constant, as will be evident from the following table, which brings out the difference in work-hardness between the three plates. In each case the value of the sheet softened both at 500 deg. and 250 deg. is given.

Fig. 3 shows that in the case of all three plates the softening at 500 deg. C. is extremely rapid. The greater part of the work-hardness is lost in the first hour, and very little of it remains at the end of 24 hours. The loss is complete in about 100 hours. At 250 deg. C. the rate

of loss of work-hardness is also rapid, though less so than in the previous cases. Softening is complete at the end of about 800 hours, but the rate of loss is relatively greater during the earlier stages in the thinner sheets. The $\frac{1}{16}$ in. and $\frac{1}{25}$ in. sheets had lost by far the greater part of their work-hardness after 48 hours, whereas the $\frac{1}{8}$ in. sheet had lost appreciably less. From a practical point of view the results obtained at 125 deg. C., where the retention of work-hardness is much more prolonged, are probably the most interesting. These tests were continued for a period of 5,200 hours (0·60 year). It will be seen from Fig. 3 that the rate of loss was very similar in all three cases, and was comparatively slow.

The original and final values are contained in the subjoined table :—

Thickness.	Ultimate Stress. Tons per Sq. In.		Loss of Work-Hardness. Tons per Sq. In.	
	Original Tenacity.	Tenacity after 5,200 Hours.	Actual.	Percentage.
$\frac{1}{8}$ in. thick	11·08	9·65	1·43	27·0
$\frac{1}{16}$ in. thick	11·14	9·48	1·66	33·0
$\frac{1}{25}$ in. thick	11·78	10·01	1·77	29·6

The actual loss in work-hardness increased the thinner the original sheet, *i.e.*, the greater the work done on the sheet the greater the actual loss. If the figures of the percentage loss be compared, it will be seen that the lowest value was obtained for the $\frac{1}{8}$-in. sheet and the highest for the $\frac{1}{25}$-in. sheet. The average rate of loss, however, was greatest neither for the thickest nor the thinnest sheet. Viewing the results as a whole within the variations of thickness tested, the differences in the rate of loss of work-hardness were not large, but they tended to be greater, the greater amount of work done on the sheet.

The Influence of Composition.—This has been tested on sheets of constant thickness, but of three different compositions, viz., about 98·9 per cent., 99·17 per cent. and 99·65 per cent. purity. The sheets have been tested at 500 deg. and 250 deg. C. in all cases, and in two cases at 125 deg. C. There are therefore in all eight series of tests. The results are shown graphically in Fig. 4. It is important to note that, in spite of the differences in purity, the three sheets all fall within the Al + X area of Dr. Hanson's diagram (Fig. 2). The position of the 98·9 purity sheet is indicated in that figure ; those of the two purer sheets are to be found by inspection and lie correspondingly closer to the apex of the field in question. Constitutionally, therefore, the alloys are of the same general type, and only differ in the proportions of the aluminium-rich phase and X, a constituent which, according to the best information available, contains aluminium, iron and silicon. It must be emphasised, therefore, that in respect of these particular tests, if the diagram is correct, the three sheets are strictly comparable.

The tenacities in the hardened and fully softened conditions have a different value in each case, being highest for the sheet containing the highest proportion of X, and diminishing with a decrease in the amount of the constituent. In two cases out of the three, the values of the sheet softened at 500 deg. and 250 deg. C. are practically the same. Rather curiously, they do not coincide in the third case (the metal of 99·17 purity). The properties of the sheets, together with the values of work-hardness, are summarised in the table at the top of the next column.

It will be seen from the table that the purer the metal the lower is the tenacity, whether in the hardened or completely softened condition. It will also be observed that the work-hardness of the sheet of intermediate purity is just about the mean of those of the other two. From Fig. 4 it is clear that at 500 deg. C. the form of the curves is very similar in each case, the rate of loss of work-hardness being extremely rapid. Most of it occurred in the first hour. At 250 deg. C. the sheets of 99·17 per cent. and 99·65 per cent. purity behaved very similarly. The rate of loss of work-hardness was very rapid. The former sheet was softened in 51 hours, the latter in about 96 hours. The sheet of 98·9 per cent. purity lost its work-hardness at a noticeably slower rate, and the softening was not complete until after about 800 hours. At this temperature, therefore, the greater proportion of X present in the metal enables it to retain its work-hardness for a longer period. From a practical point of view, however, this must be regarded as a period of very short duration, and from this standpoint the most interesting results appear to be those obtained at 125 deg. C. In this case a comparison of the behaviour of the sheets of 98·9 per cent. purity was obtained. The actual tests were carried out for a total period of 2·76 years, but owing to the interruption in the tests already referred to, followed by the cooling of the specimens to the ordinary temperature, it is only possible to compare their behaviour for a period of about 5,000 hours. The following results were obtained. They are also shown graphically in Fig. 4 :—

Composition. Aluminium per Cent.	Sheets $\frac{1}{8}$ In. Thick. Tenacity. Tons per Sq. In. Hardened.	Softened— At 500 Deg.	Softened— At 250 Deg.	Work-Hardness. Tons per Sq. In.
98·9	10·80	5·76	5·76	5·04
99·2	9·45	5·43	5·18	4·27*
99·6	7·92	4·32	4·33	3·60

* In calculating this figure, the tenacity of the sheet softened at 250 deg. C. has been used.

Composition. Aluminium per Cent.	Tons per Sq. In. Tenacity of Original Sheet.	Tenacity after 5,000 Hours.	Loss of Work-Hardness.	Percentage Loss of Work-Hardness.
98·9	11·98	9·65	1·43	26·9
99·65	7·92	7·48	0·44	12·2

It appears from these figures that the purer sheet retained its work-hardness more than twice as well as the sheet of lower purity. The former, therefore, under the conditions of the test was a more stable material.

Limits of Elasticity.—In the paper by Mr. Taverner and one of the authors already referred to, values were given of the "Primitive Elastic Limit" of the sheet $\frac{1}{8}$ in. thick and 98·9 per cent. purity. These were found to be 3·4 tons and 3·5 tons per square inch, the ultimate stresses being 11·52 tons and 11·37 tons per square inch respectively. These values were determined by Dr. Stanton, who reported that the test-pieces had quite definite elastic limits, but that evidences of a yield-point were very slight. It appeared important to have corresponding determinations made of the elastic limit of the sheet fully softened by annealing. Three test-pieces were annealed for 48 hours at 550 deg. C., a heat-treatment which produces the required condition. Dr. Stanton kindly carried out the tests for the authors, and his values will be found in the subjoined table :—

"Test Mark."	EY. 1.	EY. 2.	EY. 3.
Marks on test-piece ..	533–4	534–4	535–4
Dimensions of test-piece (in.)	0·127×0·625	0·127×0·625	0·126×0·625
Cross-sectional area of test-piece (sq. in.)	0·0794	0·0794	0·0788
"Primitive" elastic limit (tons per sq. in.)	1·4	1·1	1·1
Ultimate stress (tons per sq. in.) ..	5·99	5·93	5·93
Per cent. extension (including fracture) :			
On 3 in.	30·0	31·7	32·0
On 2 in.	34·0	34·5	37·0
On 1 in.	40·0*	46·0	46·0
Modulus of elasticity (lb. per sq. in.) ..	9·8 × 10⁶	10·3 × 10⁶	10·4 × 10⁶

"*Note.*—After about 3 tons per square inch the bars stretched by a series of jerks. Fig. 5 gives the stress-strain curves with these points smoothed out. The curves were obtained by measuring the extensions with dividers.

"Fig. 6 gives the curves until well past the elastic limit, and were obtained by a mirror extensometer."

* Fracture 0·1 from gauge mark.

Taking for the "primitive" elastic limit 1·1 ton as the most probable figure, it appears that the elastic limit of the completely softened metal is only about one-third that of the metal of the degree of work-hardness tested. Against this the ultimate stress is rather more than one-half. It is realised, however, that for most purposes a knowledge of the elastic limit is even more important than that of the ultimate stress, since the usefulness of the material depends upon the elastic limit not being exceeded. It is therefore interesting to note that Dr. Stanton's tests show that the fully softened sheet has a definite, if rather low, elastic limit. It will be observed that no yield point was detected in any tests of the annealed sheets. It was discovered faintly in only one of the tests on the hardened sheet. It is therefore very doubtful whether aluminium of the quality tested has a yield-point. It will be observed that Dr. Stanton's tests also contain values of the modulus of elasticity.

Fig. 3. EFFECT OF THICKNESS. SHEETS B, C, 1 AND 4.

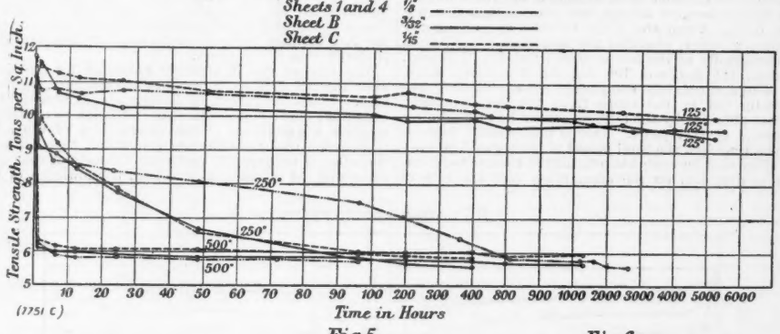


Fig. 4. EFFECT OF PURITY. SHEETS D, E, 1 and 4.

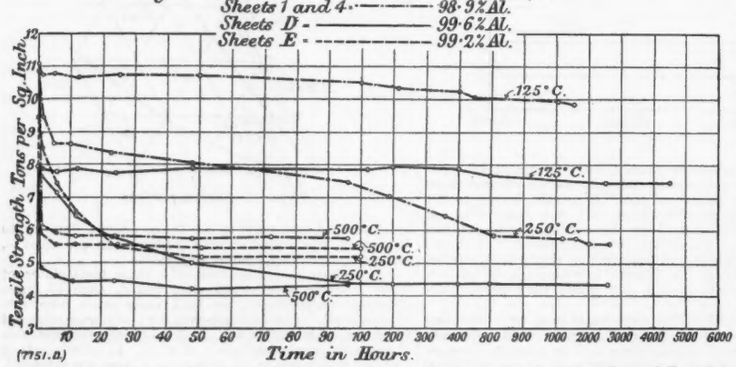


Fig. 5.

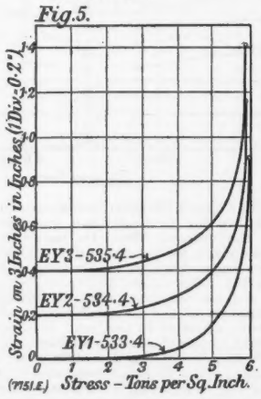
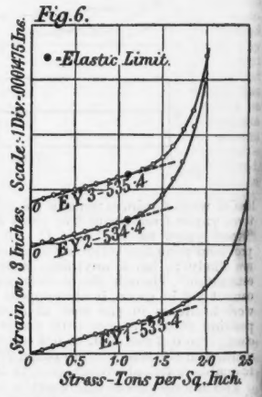


Fig. 6.



THE SUPPOSED FORMATION OF HELIUM FROM HYDROGEN.—Modern speculations having redirected attention to the supposed conversion of hydrogen into helium and neon by long-continued electric discharges, Professor Arnaldo Piutti, of Naples, has repeated his former experiments of this kind. Large aluminium electrodes were used and unusual precautions observed. None of the 70 series of experiments gave any spectroscopic indication of a partial conversion of hydrogen into either helium or neon, such as Collie and Patterson and Masson and others had claimed, and Strutt, Merton and others had been unable to confirm. On the other hand, Piutti did not fail to observe the lines of helium and of neon when small quantities of air were admitted into his discharge tubes.